

Exhibit 2

The Statewide population = 13,002,700		
The Average population per district = 764,865		
DISTRICT	POPULATION	DEVIATION
1	764,865	+0 (0.00%)
2	764,865	+0 (0.00%)
3	764,865	+0 (0.00%)
4	764,865	+0 (0.00%)
5	764,865	+0 (0.00%)
6	764,865	+0 (0.00%)
7	764,864	-1 (0.00%)
8	764,864	-1 (0.00%)
9	764,864	-1 (0.00%)
10	764,865	+0 (0.00%)
11	764,865	+0 (0.00%)
12	764,865	+0 (0.00%)
13	764,864	-1 (0.00%)
14	764,865	+0 (0.00%)
15	764,864	-1 (0.00%)
16	764,865	+0 (0.00%)
17	764,865	+0 (0.00%)

Preliminary Plan Amendment 1

LEGISLATIVE DATA PROCESSING CENTER

COMPOSITE LISTING

OF

CONGRESSIONAL DISTRICTS

<u>DISTRICT NUMBER</u>	<u>DESCRIPTION</u>
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Dist. 01 BUCKS and MONTGOMERY Counties.

All of BUCKS County and Part of MONTGOMERY County consisting of the TOWNSHIPS of Franconia, Hatfield, Horsham (PART, Districts 02 [PART, Divisions 01, 01 and 03] and 04 [PART, Divisions 02 and 03]), Marlborough, Montgomery, Salford and Upper Hanover and the BOROUGHS of East Greenville, Green Lane, Hatfield, Lansdale, Pennsbury, Red Hill, Souderton and Telford (Montgomery County Portion).

Total population: 764,865

Dist. 02 PHILADELPHIA County.

Part of PHILADELPHIA County consisting of the CITY of Philadelphia (PART, Wards 01 [PART, Division 17], 02, 05, 07, 08 [PART, Divisions 26, 30, 32 and 34], 14, 16 [PART, Divisions 01, 02, 03, 04 and 05], 18, 19, 20, 23, 25, 31, 33, 35, 37, 41, 42, 43, 45, 47 [PART, Divisions 01, 02, 03, 04, 05, 06, 07, 08 and 12], 53, 54, 55, 56, 57, 58 [PART, Divisions 02, 04, 05, 06, 12, 13, 14, 20, 21, 22, 23, 24, 25, 28, 29, 31, 34, 35, 37, 39, 40, 41 and 42], 61, 62, 63, 64, 65 and 66).

Total population: 764,865

CONGRESSIONAL DISTRICTS

Dist. 03 PHILADELPHIA County.

Part of PHILADELPHIA County consisting of the CITY of Philadelphia (PART, Wards 01 [PART, Divisions 01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20 and 21], 03, 04, 06, 08 [PART, Divisions 01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 27, 28, 29, 31, 33 and 35], 09, 10, 11, 12, 13, 15, 16 [PART, Divisions 06, 07, 08, 09, 10, 11, 12, 13, 14, 15, 16, 17 and 18], 17, 21, 22, 24, 27, 28, 29, 30, 32, 34, 36, 38, 39 [PART, Divisions 01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45 and 46], 40 [PART, Divisions 02, 03, 04, 06, 07, 10, 12, 13, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 32 and 33], 44, 46, 47 [PART, Divisions 09, 10, 11, 13 and 14], 48, 49, 50, 51, 52, 59 and 60].
Total population: 764,865

Dist. 04 MONTGOMERY and PHILADELPHIA Counties.

Part of MONTGOMERY County consisting of the TOWNSHIPS of Abington, Cheltenham, Douglass, East Norriton, Horsham (PART, Districts 01, 02 [PART, Divisions 02 and 04], 03 and 04 [PART, Divisions 01, 02 and 04]), Limerick, Lower Frederick, Lower Gwynedd, Lower Merion, Lower Moreland, Lower Pottsgrove, Lower Providence, Lower Salford, New Hanover, Perkiomen, Plymouth, Skippack, Springfield, Towamencin, Upper Dublin, Upper Frederick, Upper Gwynedd, Upper Merion, Upper Moreland, Upper Pottsgrove, Upper Providence, Upper Salford, West Norriton, West Pottsgrove, Whitemarsh, Whitpain and Worcester and the BOROUGHS of Ambler, Bridgeport, Bryn Athyn, Collegeville, Conshohocken, Hatboro, Jenkintown, Narberth, Norristown, North Wales, Pottstown, Rockledge, Royersford, Schwenksville, Trappe and West Conshohocken and Part of PHILADELPHIA County consisting of the CITY of Philadelphia (PART, Ward 58 [PART, Divisions 01, 03, 07, 08, 09, 10, 11, 15, 16, 17, 18, 19, 26, 27, 30, 32, 33, 36, 38, 43 and 44]).
Total population: 764,865

CONGRESSIONAL DISTRICTS

Dist. 05 **CHESTER, DELAWARE and PHILADELPHIA Counties.**
Part of CHESTER County consisting of the TOWNSHIPS of Birmingham, East Bradford, East Goshen, East Marlborough, Kennett, New Garden, Pennsbury, Pocopson, Thornbury, West Goshen, West Whiteland (PART, Precincts 01, 02, 03 and 04 (all blocks except 1016 and 3000 of tract 302205)) and Westtown and the BOROUGHS of Kennett Square and West Chester; All of DELAWARE County and Part of PHILADELPHIA County consisting of the CITY of Philadelphia (PART, Wards 26, 39 [PART, Division 14] and 40 [PART, Divisions 01, 05, 08, 09, 11, 14, 15, 16, 27, 28, 29, 30, 31, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50 and 51]).
Total population: 764,865

CONGRESSIONAL DISTRICTS

Dist. 06 BERKS and CHESTER Counties.
Part of BERKS County consisting of the CITY of Reading and the TOWNSHIPS of Alsace, Amity, Bern, Bethel, Brecknock, Caernarvon, Centre (PART, Precincts 01 and 02 (only blocks 1029, 1030, 1031, 1033, 1034, 1039, 1044, 1045, 1046, 3010, 3012, 3013, 3014, 3021, 3022, 3023, 3024, 3025, 3026, 3027, 3028, 3029, 3037, 3042, 3050, 3056, 3059 and 3066 of tract 010201)), Colebrookdale, Cumru, District, Douglass, Earl, Exeter, Heidelberg, Jefferson, Lower Alsace, Lower Heidelberg, Maidencreek, Marion, Muhlenberg, North Heidelberg, Oley, Ontelaunee, Penn, Pike, Robeson, Rockland, Ruscombmanor, South Heidelberg, Spring, Tulpehocken, Union, Upper Bern and Upper Tulpehocken and the BOROUGHS of Adamstown (Berks County Portion), Bernville, Birdsboro, Boyertown, Kenhorst, Laureldale, Leesport, Mohnton, Mount Penn, New Morgan, Robesonia, Shillington, Sinking Spring, St. Lawrence, Wernersville, West Reading, Womelsdorf and Wyomissing and Part of CHESTER County consisting of the CITY of Coatesville and the TOWNSHIPS of Caln, Charlestown, East Brandywine, East Caln, East Coventry, East Fallowfield, East Nantmeal, East Nottingham, East Pikeland, East Vincent, East Whiteland, Easttown, Elk, Franklin, Highland, Honey Brook, London Britain, London Grove, Londonderry, Lower Oxford, New London, Newlin, North Coventry, Penn, Sadsbury, Schuylkill, South Coventry, Tredyffrin, Upper Oxford, Upper Uwchlan, Uwchlan, Valley, Wallace, Warwick, West Bradford, West Brandywine, West Caln, West Fallowfield, West Marlborough, West Nantmeal, West Nottingham, West Pikeland, West Sadsbury, West Vincent, West Whiteland (PART, Precincts 04 (only blocks 1016 and 3000 of tract 302205), 05, 06 and 07) and Willistown and the BOROUGHS of Atglen, Avondale, Downingtown, Elverson, Honey Brook, Malvern, Modena, Oxford, Parkesburg, Phoenixville, South Coatesville, Spring City and West Grove.
Total population: 764,865

CONGRESSIONAL DISTRICTS

Dist. 07 BERKS, LEHIGH, MONROE and NORTHAMPTON Counties.
Part of BERKS County consisting of the TOWNSHIPS of Albany, Centre (PART, Precinct 02 (all blocks except 1029, 1030, 1031, 1033, 1034, 1039, 1044, 1045, 1046, 3010, 3012, 3013, 3014, 3021, 3022, 3023, 3024, 3025, 3026, 3027, 3028, 3029, 3037, 3042, 3050, 3056, 3059 and 3066 of tract 010201)), Greenwich, Hereford, Longswamp, Maxatawny, Perry, Richmond, Tilden, Washington and Windsor and the BOROUGHS of Bally, Bechtelsville, Centerport, Fleetwood, Hamburg, Kutztown, Lenhartsville, Lyons, Shoemakersville and Topton; All of LEHIGH County; Part of MONROE County consisting of the TOWNSHIPS of Eldred, Hamilton, Ross and Stroud (PART, Districts 05 (only blocks 2015, 2016, 2017 and 2018 of tract 301002), 06 and 07) and All of NORTHAMPTON County.
Total population: 764,864

CONGRESSIONAL DISTRICTS

Dist. 08 BRADFORD, LACKAWANNA, LUZERNE, MONROE, PIKE,
SUSQUEHANNA, WAYNE and WYOMING Counties.
All of BRADFORD County; All of LACKAWANNA County; Part
of LUZERNE County consisting of the CITIES of Pittston
and Wilkes-Barre and the TOWNSHIPS of Dallas, Exeter,
Franklin, Jackson, Jenkins, Kingston, Lake, Lehman,
Pittston, Plains, Plymouth, Ross and Wilkes-Barre and
the BOROUGHS of Avoca, Dallas, Dupont, Duryea, Exeter,
Forty Fort, Harveys Lake, Hughestown, Kingston,
Laflin, Laurel Run, Luzerne (PART, (all blocks except
2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008,
2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017,
2018, 2019, 2020, 2021, 3003, 3004, 3005, 3006, 3007,
3008, 3009, 3010, 3011, 3012, 3013, 3018, 3019, 3026,
3027 and 3028 of tract 212300)), Swoyersville, West
Pittston, West Wyoming, Wyoming and Yatesville; Part
of MONROE County consisting of the TOWNSHIPS of
Barrett, Chestnuthill, Coolbaugh, Jackson, Middle
Smithfield, Paradise, Pocono, Polk, Price, Smithfield,
Stroud (PART, Districts 01, 02, 03, 04 and 05 (all
blocks except 2015, 2016, 2017 and 2018 of tract
301002)), Tobyhanna and Tunkhannock and the BOROUGHS
of Delaware Water Gap, East Stroudsburg, Mount Pocono
and Stroudsburg; All of PIKE County; All of
SUSQUEHANNA County; All of WAYNE County and All of
WYOMING County.
Total population: 764,864

CONGRESSIONAL DISTRICTS

Dist. 09 CARBON, CLINTON, COLUMBIA, LUZERNE, LYCOMING, MONTOUR, NORTHUMBERLAND, POTTER, SCHUYLKILL, SNYDER, SULLIVAN, TIOGA and UNION Counties.
All of CARBON County; Part of CLINTON County consisting of the TOWNSHIP of Pine Creek (PART, District 01 (all blocks except 1007, 1008, 1010, 1011, 1037, 1064, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2013, 2015, 2016, 2022, 2023, 2024, 2025, 2027, 2028, 2057, 2059, 3000 and 3021 of tract 030400)) and the BOROUGH of Avis; All of COLUMBIA County; Part of LUZERNE County consisting of the CITIES of Hazleton and Nanticoke and the TOWNSHIPS of Bear Creek, Black Creek, Buck, Butler, Conyngham, Dennison, Dorrance, Fairmount, Fairview, Foster, Hanover, Hazle, Hollenback, Hunlock, Huntington, Nescopeck, Newport, Rice, Salem, Slocum, Sugarloaf, Union and Wright and the BOROUGHS of Ashley, Bear Creek Village, Conyngham, Courtdale, Edwardsville, Freeland, Jeddo, Larksville, Luzerne (PART, (all blocks except 1000, 1001, 1002, 1003, 1004, 1005, 1006, 1007, 1008, 1009, 1010, 1011, 1012, 1013, 1014, 1015, 1016, 1017, 1018, 1019, 1020, 1021, 1022, 1023, 1024, 3000, 3001, 3002, 3014, 3015, 3016, 3017, 3020, 3021, 3022, 3023, 3024 and 3025 of tract 212300)), Nescopeck, New Columbus, Nuangola, Penn Lake Park, Plymouth, Pringle, Shickshinny, Sugar Notch, Warrior Run, West Hazleton and White Haven; All of LYCOMING County; All of MONTOUR County; All of NORTHUMBERLAND County; All of POTTER County; All of SCHUYLKILL County; Part of SNYDER County consisting of the TOWNSHIPS of Chapman, Jackson, Middlecreek, Monroe, Penn, Union and Washington and the BOROUGHS of Freeburg, Selinsgrove and Shamokin Dam; All of SULLIVAN County; All of TIOGA County and Part of UNION County consisting of the TOWNSHIPS of Buffalo (PART, District 01 (only blocks 2034, 2035, 2036, 2037, 2044, 2045, 2047, 2056, 2057, 2058, 2059, 2060, 2061, 2062 and 2063 of tract 090502)), East Buffalo, Kelly and Union and the BOROUGH of Lewisburg.
Total population: 764,864

CONGRESSIONAL DISTRICTS

Dist. 10 ADAMS, CUMBERLAND, DAUPHIN and YORK Counties.
All of ADAMS County; Part of CUMBERLAND County consisting of the TOWNSHIPS of East Pennsboro, Hampden, Lower Allen, Monroe, Silver Spring (PART, Precincts 02 (all blocks except 2020, 2021, 2026, 2027, 2028, 2029 and 2030 of tract 011806), 03, 04, 05, 06, 07, 08 and 09) and Upper Allen and the BOROUGHS of Camp Hill, Lemoyne, Mechanicsburg, New Cumberland, Shiremanstown and Wormleysburg; Part of DAUPHIN County consisting of the CITY of Harrisburg and All of YORK County.
Total population: 764,865

Dist. 11 DAUPHIN, LANCASTER and LEBANON Counties.
Part of DAUPHIN County consisting of the TOWNSHIPS of Conewago, Derry, East Hanover (PART, Precinct 01 (only blocks 2077, 2078, 2081, 2082, 2083, 2084, 3013, 3014, 3016, 3017, 3018, 3019, 3020, 3021, 3022, 3023, 3024, 3025, 3026, 3027, 3028, 3029, 3030, 3031, 3032, 3033, 3034, 3035, 3036, 3037, 3038, 3039, 3040, 3041, 3042, 3043 and 3044 of tract 024502)), Londonderry, Lower Swatara and South Hanover and the BOROUGHS of Highspire, Hummelstown, Middletown and Royalton; All of LANCASTER County and All of LEBANON County.
Total population: 764,865

CONGRESSIONAL DISTRICTS

Dist. 12 ARMSTRONG, BUTLER, CAMBRIA, CAMERON, CENTRE, CLARION, CLEARFIELD, CLINTON, ELK, FOREST, INDIANA, JEFFERSON, MCKEAN and WARREN Counties.

All of ARMSTRONG County; Part of BUTLER County consisting of the TOWNSHIPS of Allegheny, Buffalo, Clearfield, Clinton, Donegal, Fairview, Jefferson, Parker, Summit (PART, District South (only blocks 1012, 1013, 1015, 1016, 1020, 1021, 1022, 1023, 1024, 1025, 1026, 1027, 1028, 1029, 1030, 1031, 3042, 3049, 3050 and 3051 of tract 911200)) and Winfield and the BOROUGHS of Bruin, Chicora, Fairview, Karns City, Petrolia and Saxonburg; Part of CAMBRIA County consisting of the CITY of Johnstown and the TOWNSHIPS of Allegheny, Barr, Blacklick, Cambria, Chest, Clearfield, Cresson, Croyle, Dean, East Carroll, East Taylor, Elder, Gallitzin, Jackson, Lower Yoder, Middle Taylor, Munster, Portage, Reade, Stonycreek (PART, District 02), Summerhill, Susquehanna, Upper Yoder, Washington, West Carroll, West Taylor and White and the BOROUGHS of Ashville, Brownstown, Carrolltown, Cassandra, Chest Springs, Cresson, Daisytown, Dale, East Conemaugh, Ebensburg, Ehrenfeld, Ferndale, Franklin, Gallitzin, Hastings, Lilly, Lorain, Loretto, Nanty Glo, Northern Cambria, Patton, Portage, Sankertown, South Fork, Southmont, Summerhill, Tunnelhill (Cambria County Portion), Vintondale, Westmont and Wilmore; All of CAMERON County; All of CENTRE County; All of CLARION County; All of CLEARFIELD County; Part of CLINTON County consisting of the CITY of Lock Haven and the TOWNSHIPS of Allison, Bald Eagle, Beech Creek, Castanea, Chapman, Colebrook, Crawford, Dunnstable, East Keating, Gallagher, Greene, Grugan, Lamar, Leidy, Logan, Noyes, Pine Creek (PART, Districts 01 (only blocks 1007, 1008, 1010, 1011, 1037, 1064, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2013, 2015, 2016, 2022, 2023, 2024, 2025, 2027, 2028, 2057, 2059, 3000 and 3021 of tract 030400) and 02), Porter, Wayne, West Keating and Woodward and the BOROUGHS of Beech Creek, Flemington, Loganton, Mill Hall, Renovo and South Renovo; All of ELK County; All of FOREST County; All of INDIANA County; All of JEFFERSON County; All of MCKEAN County and All of WARREN County.

Total population: 764,865

CONGRESSIONAL DISTRICTS

Dist. 13 BLAIR, CUMBERLAND, DAUPHIN, FRANKLIN, FULTON,
HUNTINGDON, JUNIATA, MIFFLIN, PERRY, SNYDER and UNION
Counties.

All of BLAIR County; Part of CUMBERLAND County
consisting of the TOWNSHIPS of Cooke, Dickinson,
Hopewell, Lower Frankford, Lower Mifflin, Middlesex,
North Middleton, North Newton, Penn, Shippensburg,
Silver Spring (PART, Precincts 01 and 02 (only blocks
2020, 2021, 2026, 2027, 2028, 2029 and 2030 of tract
011806)), South Middleton, South Newton, Southampton,
Upper Frankford, Upper Mifflin and West Pennsboro and
the BOROUGHS of Carlisle, Mount Holly Springs,
Newburg, Newville and Shippensburg (Cumberland County
Portion); Part of DAUPHIN County consisting of the
TOWNSHIPS of East Hanover (PART, Precincts 01 (all
blocks except 2077, 2078, 2081, 2082, 2083, 2084,
3013, 3014, 3016, 3017, 3018, 3019, 3020, 3021, 3022,
3023, 3024, 3025, 3026, 3027, 3028, 3029, 3030, 3031,
3032, 3033, 3034, 3035, 3036, 3037, 3038, 3039, 3040,
3041, 3042, 3043 and 3044 of tract 024502) and 02),
Halifax, Jackson, Jefferson, Lower Paxton, Lykens,
Middle Paxton, Mifflin, Reed, Rush, Susquehanna,
Swatara, Upper Paxton, Washington, Wayne, West
Hanover, Wiconisco and Williams and the BOROUGHS of
Berrysburg, Dauphin, Elizabethville, Gratz, Halifax,
Lykens, Millersburg, Paxtang, Penbrook, Pillow,
Steelton and Williamstown; All of FRANKLIN County;
All of FULTON County; All of HUNTINGDON County; All
of JUNIATA County; All of MIFFLIN County; All of PERRY
County; Part of SNYDER County consisting of the
TOWNSHIPS of Adams, Beaver, Center, Franklin, Perry,
Spring, West Beaver and West Perry and the BOROUGHS
of Beavertown, McClure and Middleburg and Part of
UNION County consisting of the TOWNSHIPS of Buffalo
(PART, Districts 01 (all blocks except 2034, 2035,
2036, 2037, 2044, 2045, 2047, 2056, 2057, 2058, 2059,
2060, 2061, 2062 and 2063 of tract 090502) and 02),
Gregg, Hartley, Lewis, Limestone, West Buffalo and
White Deer and the BOROUGHS of Hartleton, Mifflinburg
and New Berlin.

Total population: 764,864

CONGRESSIONAL DISTRICTS

Dist. 14 BEDFORD, CAMBRIA, FAYETTE, GREENE, SOMERSET, WASHINGTON and WESTMORELAND Counties.
All of BEDFORD County; Part of CAMBRIA County consisting of the TOWNSHIPS of Adams, Conemaugh, Richland and Stonycreek (PART, Districts 01, 03 and 04) and the BOROUGHHS of Geistown and Scalp Level; All of FAYETTE County; All of GREENE County; All of SOMERSET County; Part of WASHINGTON County consisting of the CITY of Monongahela and the TOWNSHIPS of Amwell (PART, District 02), Blaine, Carroll, Donegal, East Bethlehem, East Finley, Fallowfield, Independence (PART, District 01), Morris, North Franklin (PART, District 01), Nottingham, Peters, Somerset, South Franklin, Union, West Bethlehem, West Finley and West Pike Run and the BOROUGHHS of Allenport, Beallsville, Bentleyville, California, Centerville, Charleroi, Claysville, Coal Center, Cokeburg, Deemston, Donora, Dunlevy, Elco, Ellsworth, Finleyville, Long Branch, Marianna, New Eagle, North Charleroi, Roscoe, Speers, Stockdale, Twilight and West Brownsville and All of WESTMORELAND County.
Total population: 764,865

Dist. 15 ALLEGHENY County.
Part of ALLEGHENY County consisting of the CITIES of Clairton, Duquesne, McKeesport and Pittsburgh and the TOWNSHIPS of Baldwin, Elizabeth, Forward, Mount Lebanon, North Versailles, Penn Hills, Reserve, South Park, South Versailles, Stowe (PART, Wards 01, 02 [PART, Division 01], 06 and 09) and Wilkins and the BOROUGHHS of Baldwin, Bethel Park, Braddock, Braddock Hills, Brentwood, Castle Shannon, Chalfant, Churchill, Dormont, Dravosburg, East McKeesport, East Pittsburgh, Edgewood, Elizabeth, Forest Hills, Glassport, Homestead, Jefferson Hills, Liberty, Lincoln, McKees Rocks, Monroeville, Mount Oliver, Munhall, North Braddock, Pitcairn, Pleasant Hills, Plum, Port Vue, Rankin, Swissvale, Trafford (Allegheny County Portion), Turtle Creek, Versailles, Wall, West Elizabeth, West Homestead, West Mifflin, Whitaker, White Oak, Whitehall, Wilkinsburg and Wilmerding.
Total population: 764,864

CONGRESSIONAL DISTRICTS

Dist. 16 BUTLER, CRAWFORD, ERIE, LAWRENCE, MERCER and VENANGO Counties.

Part of BUTLER County consisting of the CITY of Butler and the TOWNSHIPS of Adams, Brady, Butler, Center, Cherry, Clay, Concord, Connoquenessing, Cranberry, Forward, Franklin, Jackson, Lancaster, Marion, Mercer, Middlesex, Muddycreek, Oakland, Penn, Slippery Rock, Summit (PART, Districts North and South (all blocks except 1012, 1013, 1015, 1016, 1020, 1021, 1022, 1023, 1024, 1025, 1026, 1027, 1028, 1029, 1030, 1031, 3042, 3049, 3050 and 3051 of tract 911200)), Venango, Washington and Worth and the BOROUGHS of Callery, Cherry Valley, Connoquenessing, East Butler, Eau Claire, Evans City, Harmony, Harrisville, Mars, Portersville, Prospect, Seven Fields, Slippery Rock, Valencia, West Liberty, West Sunbury and Zelienople; All of CRAWFORD County; All of ERIE County; All of LAWRENCE County; All of MERCER County and All of VENANGO County.

Total population: 764,865

CONGRESSIONAL DISTRICTS

Dist. 17 ALLEGHENY, BEAVER and WASHINGTON Counties.
Part of ALLEGHENY County consisting of the TOWNSHIPS of Aleppo, Collier, Crescent, East Deer, Fawn, Findlay, Frazer, Hampton, Harmar, Harrison, Indiana, Kennedy, Kilbuck, Leet, Marshall, McCandless, Moon, Neville, North Fayette, O'Hara, Ohio, Pine, Richland, Robinson, Ross, Scott, Shaler, South Fayette, Springdale, Stowe (PART, Wards 02 [PART, Division 02], 03, 04, 05, 07 and 08), Upper St. Clair and West Deer and the BOROUGHS of Aspinwall, Avalon, Bell Acres, Bellevue, Ben Avon, Ben Avon Heights, Blawnox, Brackenridge, Bradford Woods, Bridgeville, Carnegie, Cheswick, Coraopolis, Crafton, Edgeworth, Emsworth, Etna, Fox Chapel, Franklin Park, Glen Osborne, Glenfield, Green Tree, Haysville, Heidelberg, Ingram, Leetsdale, McDonald (Allegheny County Portion), Millvale, Oakdale, Oakmont, Pennsbury Village, Rosslyn Farms, Sewickley, Sewickley Heights, Sewickley Hills, Sharpsburg, Springdale, Tarentum, Thornburg, Verona and West View; All of BEAVER County and Part of WASHINGTON County consisting of the CITY of Washington and the TOWNSHIPS of Amwell (PART, District 01), Buffalo, Canton, Cecil, Chartiers, Cross Creek, Hanover, Hopewell, Independence (PART, District 02), Jefferson, Mount Pleasant, North Bethlehem, North Franklin (PART, Districts 02 and 03), North Strabane, Robinson, Smith and South Strabane and the BOROUGHS of Burgettstown, Canonsburg, East Washington, Green Hills, Houston, McDonald (Washington County Portion), Midway and West Middletown.
Total population: 764,865

Population of all districts: 13,002,700

LEGISLATIVE DATA PROCESSING CENTER

12/13/2021

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COUNTIES SPLIT BY CONGRESSIONAL DISTRICTS

15 TOTAL COUNTIES

18 TOTAL SPLITS

ALLEGHENY

015 017

BERKS

006 007

BUTLER

012 016

CAMBRIA

012 014

CHESTER

005 006

CLINTON

009 012

CUMBERLAND

010 013

DAUPHIN

010 011 013

LUZERNE

008 009

MONROE

007 008

MONTGOMERY

001 004

PHILADELPHIA

002 003 004 005

SNYDER

009 013

UNION

009 013

WASHINGTON

014 017

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PLACES SPLIT BY CONGRESSIONAL DISTRICTS

16 TOTAL PLACES

18 TOTAL SPLITS

ALLEGHENY COUNTY

STOWE TOWNSHIP 015 017

BERKS COUNTY

CENTRE TOWNSHIP 006 007

BUTLER COUNTY

SUMMIT TOWNSHIP 012 016

CAMBRIA COUNTY

STONYCREEK TOWNSHIP 012 014

CHESTER COUNTY

WEST WHITELAND TOWNSHIP 005 006

CLINTON COUNTY

PINE CREEK TOWNSHIP 009 012

CUMBERLAND COUNTY

SILVER SPRING TOWNSHIP 010 013

DAUPHIN COUNTY

EAST HANOVER TOWNSHIP 011 013

LUZERNE COUNTY

LUZERNE BOROUGH 008 009

MONROE COUNTY

STROUD TOWNSHIP 007 008

MONTGOMERY COUNTY

HORSHAM TOWNSHIP 001 004

PHILADELPHIA COUNTY

PHILADELPHIA CITY 002 003 004 005

UNION COUNTY

BUFFALO TOWNSHIP 009 013

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PLACES SPLIT BY CONGRESSIONAL DISTRICTS

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WASHINGTON COUNTY

AMWELL	TOWNSHIP	014 017
INDEPENDENCE	TOWNSHIP	014 017
NORTH FRANKLIN	TOWNSHIP	014 017

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WARDS SPLIT BY CONGRESSIONAL DISTRICTS

19 TOTAL WARDS 19 TOTAL SPLITS

ALLEGHENY COUNTY		
STOWE	TOWNSHIP	
WARD 02		015 017
BERKS COUNTY		
CENTRE	TOWNSHIP	
WARD 02		006 007
BUTLER COUNTY		
SUMMIT	TOWNSHIP	
WARD SOUTH		012 016
CHESTER COUNTY		
WEST WHITELAND	TOWNSHIP	
WARD 04		005 006
CLINTON COUNTY		
PINE CREEK	TOWNSHIP	
WARD 01		009 012
CUMBERLAND COUNTY		
SILVER SPRING	TOWNSHIP	
WARD 02		010 013
DAUPHIN COUNTY		
EAST HANOVER	TOWNSHIP	
WARD 01		011 013
LUZERNE COUNTY		
LUZERNE	BOROUGH	
WARD		008 009
MONROE COUNTY		
STROUD	TOWNSHIP	
WARD 05		007 008
MONTGOMERY COUNTY		
HORSHAM	TOWNSHIP	
WARD 02		001 004
WARD 04		001 004

LEGISLATIVE DATA PROCESSING CENTER
WARDS SPLIT BY CONGRESSIONAL DISTRICTS

12/13/2021
PAGE 2

PHILADELPHIA COUNTY

PHILADELPHIA	CITY
WARD 01	002 003
WARD 08	002 003
WARD 16	002 003
WARD 39	003 005
WARD 40	003 005
WARD 47	002 003
WARD 58	002 004

UNION COUNTY

BUFFALO	TOWNSHIP
WARD 01	009 013

Exhibit 3

Compactness Report

HB2146

[For more information on compactness calculations Click Here](#)

Compactness measure: Polsby–Popper

District	District Area (SQM)	Perimeter (Miles)	Area of Circle with Same Perimeter	Perimeter of	Compactness Value
1	713	151	1,807	95	0.39
2	65	61	291	29	0.22
3	56	55	241	27	0.23
4	399	142	1,606	71	0.25
5	339	129	1,331	65	0.25
6	1,246	284	6,424	125	0.19
7	1,071	192	2,921	116	0.37
8	4,979	421	14,125	250	0.35
9	6,984	539	23,120	296	0.30
10	1,557	211	3,536	140	0.44
11	1,455	193	2,954	135	0.49
12	10,301	557	24,711	360	0.42
13	5,350	483	18,585	259	0.29
14	5,051	520	21,491	252	0.24
15	308	116	1,070	62	0.29
16	4,896	354	9,979	248	0.49
17	1,284	260	5,383	127	0.24

Most Compact: 0.49 For District: 16

0.32

Least Compact: 0.19 For District: 6

Compactness measure: Schwartzberg

District	District Area (SQM)	Perimeter (Miles)	Area of Circle with Same Perimeter	Perimeter of	Compactness Value
1	713	151	1,807	95	0.63
2	65	61	291	29	0.47
3	56	55	241	27	0.48
4	399	142	1,606	71	0.50
5	339	129	1,331	65	0.50
6	1,246	284	6,424	125	0.44
7	1,071	192	2,921	116	0.61
8	4,979	421	14,125	250	0.59
9	6,984	539	23,120	296	0.55
10	1,557	211	3,536	140	0.66
11	1,455	193	2,954	135	0.70
12	10,301	557	24,711	360	0.65
13	5,350	483	18,585	259	0.54
14	5,051	520	21,491	252	0.48
15	308	116	1,070	62	0.54
16	4,896	354	9,979	248	0.70
17	1,284	260	5,383	127	0.49

Most Compact: 0.7 For District: 16

0.56

Least Compact: 0.44 For District: 6

Compactness measure: Reock Score

District Area	Perimeter	Area of Circle with	Perim	Compactness

District	District Area (SQM)	Perimeter (Miles)	Area of Circle with Same Perimeter	Perimeter of Circle with Same Area	Compactness Value
1	713	151	1,807	95	0.40
2	65	61	291	29	0.30
3	56	55	241	27	0.37
4	399	142	1,606	71	0.36
5	339	129	1,331	65	0.34
6	1,246	284	6,424	125	0.38
7	1,071	192	2,921	116	0.40
8	4,979	421	14,125	250	0.41
9	6,984	539	23,120	296	0.33
10	1,557	211	3,536	140	0.44
11	1,455	193	2,954	135	0.49
12	10,301	557	24,711	360	0.62
13	5,350	483	18,585	259	0.43
14	5,051	520	21,491	252	0.38
15	308	116	1,070	62	0.58
16	4,896	354	9,979	248	0.38
17	1,284	260	5,383	127	0.45

Most Compact: 0.62 For District: 12

0.42

Least Compact: 0.3 For District: 2

Report Date: 12/13/2021 12:20:24 PM

Page: 1

Exhibit 4

Precinct Splits Population Breakdowns by District

Summit Township, Butler County, Population Total: 4,504

District 12	District 16
3,678	826

Pine Creek Township, Clinton County, Population Total: 3,416

District 9	District 12
1,289	2,127

Buffalo Township, Union County, Population total: 3,593

District 9	District 13
340	3,253

Silver Spring Township, Cumberland County. Population Total: 19,557

District 10	District 13
17,009	2,548

East Hanover Township, Dauphin County, Population Total: 6,019

District 11	District 11
1,370	4,649

Luzerne Borough, Luzerne County, Population Total: 2,711

District 8	District 9
1,196	1,515

Stroud Township, Monroe County, Population total: 19,834

District 7	District 8
2,898	16,936

Centre Township, Berks County, Population: 3,938

District 6	District 7
2,678	1,260

West Whiteland Township, Chester County, Population total: 19,632

District 5	District 6
10,509	9,123

CERTIFICATE OF COMPLIANCE

I hereby certify that this filing complies with the provisions of the Case Records Public Access Policy of the Unified Judicial System of Pennsylvania that require filing confidential information and documents differently than non-confidential information and documents.

/s/ Jeffry Duffy
Jeffry Duffy (PA No. 081670)

CERTIFICATE OF SERVICE

I hereby certify that on January 24, 2022, a copy of the foregoing filing was served on all counsel of record via PACFile.

/s/ Jeffry Duffy
Jeffry Duffy (PA No. 081670)

122042.000003 4882-3764-9163

Report on Proposed
Congressional Redistricting Plan
from the Pennsylvania House Republican
Caucus

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1 Introduction and Qualifications

I have been asked by counsel to review the Pennsylvania House of Representatives Republican Caucus' proposed congressional redistricting plan (hereafter, "HB2146 plan") and compare it to a set of simulated redistricting plans across a number of factors commonly considered in the redistricting process and in redistricting litigation. To do this, I implement a publicly available and peer-reviewed redistricting simulation algorithm to generate 50,000 simulated district maps, each containing 17 congressional districts. The redistricting algorithm generates a representative sample of districts by following neutral redistricting criteria without regard to partisan data. In this way, the simulated districts establish a comparison set of plans that use purely non-partisan redistricting inputs. I then compare the simulated plans against the proposed plan using a number of commonly used redistricting criteria to assess whether the proposed plan is consistent with what one would expect to see in a redistricting plan composed without reference to any racial or partisan considerations.¹ Across all measures, the proposed plan is well within the distribution of simulated plans and is unbiased, with a slight lean towards favoring Democratic candidates.

I am an associate professor of political science at Brigham Young University and faculty fellow at the Center for the Study of Elections and Democracy in Provo, Utah. I received my PhD in political science from Princeton University in 2014 with emphases in American politics and quantitative methods/statistical analyses. My dissertation was awarded the 2014 Carl Albert Award for best dissertation in the area of American Politics by the American Political Science Association.

I teach a number of undergraduate courses in American politics and quantitative research methods.² These include classes about political representation, Congressional elections, statistical methods, and research design.

I have worked as an expert witness in a number of cases in which I have been asked

¹In a later section I consider the impact of considering only the simulations that meet certain thresholds with regards to the racial composition of some districts.

²The political science department at Brigham Young University does not offer any graduate degrees.

to analyze and evaluate various political and elections-related data and statistical methods. Cases in which I have testified at trial or by deposition are listed in my CV, which is attached to the end of this report. I have previously provided expert reports in a number of cases related to voting, redistricting, and election-related issues: *Nancy Carola Jacobson, et al., Plaintiffs, vs. Laurel M. Lee, et al., Defendants. Case No. 4:18-cv-00262 MW-CAS (U.S. District Court for the Northern District of Florida); Common Cause, et al., Plaintiffs, vs. Lewis, et al., Defendants. Case No. 18-CVS-14001 (Wake County, North Carolina); Kelvin Jones, et al., Plaintiffs, v. Ron DeSantis, et al., Defendants, Consolidated Case No. 4:19-cv-300 (U.S. District Court for the Northern District of Florida); Community Success Initiative, et al., Plaintiffs, v. Timothy K. Moore, et al., Defendants, Case No. 19-cv-15941 (Wake County, North Carolina); Richard Rose et al., Plaintiffs, v. Brad Raffensperger, Defendant, Civil Action No. 1:20-cv-02921-SDG (U.S. District Court for the Northern District of Georgia); Georgia Coalition for the People's Agenda, Inc., et. al., Plaintiffs, v. Brad Raffensperger, Defendant. Civil Action No. 1:18-cv-04727-ELR (U.S. District Court for the Northern District of Georgia); Alabama, et al., Plaintiffs, v. United States Department of Commerce; Gina Raimondo, et al., Defendants. Case No. CASE NO. 3:21-cv-00211-RAH-ECM-KCN (U.S. District Court for the Middle District of Alabama Eastern Division); League of Women Voters of Ohio, et al., Relators, v. Ohio Redistricting Commission, et al., Respondents. Case No. 2021-1193 (Supreme Court of Ohio); Harper, et al., Plaintiffs, v. Hall et al., Defendants. Case No. 21-CVS-015426 (Wake County North Carolina).* I have also recently testified before the Pennsylvania Legislative Reapportionment Commission regarding the LRC's proposed map for the Pennsylvania House of Representatives.

In my position as a professor of political science, I have conducted research on a variety of election- and voting-related topics in American politics and public opinion. Much of my research uses advanced statistical methods for the analysis of quantitative data. I have worked on a number of research projects that use “big data” that include millions of observations, including a number of state voter files, campaign contribution lists, and data

from the US Census. I have also used geographic information systems and other mapping techniques in my work with political data.

Much of this research has been published in peer-reviewed journals. I have published nearly 20 peer-reviewed articles, including in our discipline's flagship journal, *The American Political Science Review* as well as the inter-disciplinary journal, *Science Advances*. My CV, which details my complete publication record, is attached to this report as Appendix A.

The analysis and opinions I provide in this report are consistent with my education, training in statistical analysis, and knowledge of the relevant academic literature. These skills are well-suited for this type of analysis in political science and quantitative analysis more generally. My conclusions stated herein are based upon my review of the information available to me at this time. I reserve the right to alter, amend, or supplement these conclusions based upon further study or based upon the availability of additional information. The opinions in this report are my own, and do not represent the view of Brigham Young University.

2 Summary of Conclusions

Based on the evidence and analysis presented below, my opinions regarding the HB2146 plan for congressional districts in Pennsylvania can be summarized as follows:

- The contemporary political geography of Pennsylvania is such that Democratic majorities are geographically clustered in the largest cities of the state while Republican voters dominate the suburban and rural portions of the state.
- This geographic clustering in cities puts the Democratic Party at a natural disadvantage when single-member districts are drawn. Specifically, districts drawn to be contiguous, compact, and contain minimal county and municipal splits will naturally create several districts in the Philadelphia and Pittsburgh areas that contain substantial Democratic majorities with many “wasted votes.”

- Based on a comparison between the HB2146 plan, and a set of 50,000 simulated maps, the HB2146 plan is a fair plan with no evidence of partisan gerrymandering across a number of different measures used to assess the fairness of a map.
- Based on an index of statewide elections from 2012-2020, the HB2146 plan generates nine Democratic-leaning districts and eight Republican-leaning districts.
- Based on the same index of statewide elections from 2012-2020, six of the districts in the HB2146 plan will likely be competitive with candidates from both parties having a realistic possibility of winning the seats. Five of these competitive districts are *extremely* competitive, with a partisan index within two percentage points of an even 50/50 split.
- Compared to a second set of simulations that explicitly consider the creation of minority opportunity districts, the HB2146 plan is similarly unbiased. The race-conscious simulations reduce the variation in Democratic-leaning districts substantially, making nine Democratic-leaning districts the overwhelmingly most likely outcome in the simulations.
- Based on these commonly-used measures of redistricting fairness, the HB2146 plan is unbiased, and when compared to the simulations on these same metrics is balanced between occasionally having a slight Republican benefit and occasionally providing a slight benefit to Democratic voters.

3 Political Geography of Pennsylvania

Scholarship in political science has noted that the spatial distribution of voters throughout a state can have an impact on the partisan outcomes of elections when a state is, by necessity, divided into a number of legislative districts. This is largely the case because Democratic-leaning voters tend to cluster in dense, urban areas while Republican-leaning voters tend to be more evenly distributed across the remainder of the state.³ One prominent study of the topic (Chen and Rodden, 2013) finds that “Democrats are highly clustered in dense central city areas, while Republicans are scattered more evenly through the suburban, exurban, and rural periphery...Precincts in which Democrats typically form majorities tend to be more homogenous and extreme than Republican-leaning precincts. When these Democratic precincts are combined with neighboring precincts to form legislative districts, the nearest neighbors of extremely Democratic precincts are more likely to be similarly extreme than is true for Republican precincts. As a result, when districting plans are completed, Democrats tend to be inefficiently packed into homogenous districts” (pg. 241).⁴

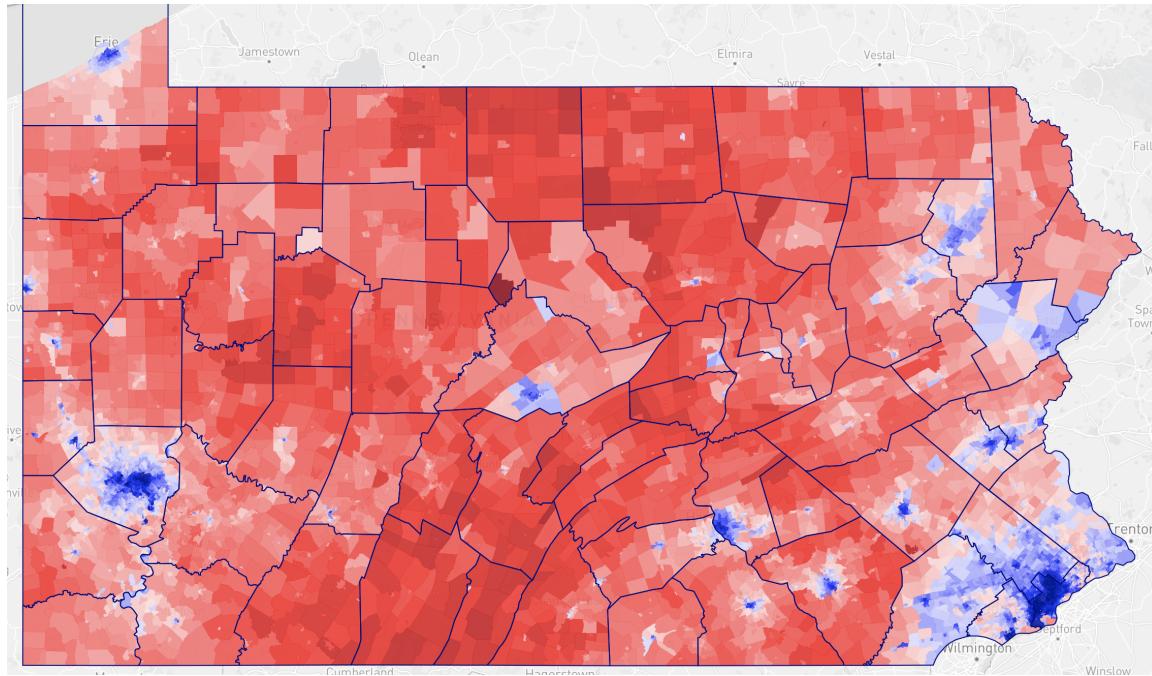
The map below confirms that this is the case in Pennsylvania. There are extremely large Democratic majorities shown in dark blue in and around Philadelphia and Pittsburgh. The remainder of the state contains smaller cities that are Democratic-leaning and large swaths of the state that are solidly Republican.

The upshot of this pattern is that a political party stands at a disadvantage when its voters are not “efficiently” distributed across the state. To understand what I mean by efficient, imagine two different scenarios. First, imagine a party with a slim majority of

³See for example Stephanopoulos, N. O. and McGhee, E. M., Partisan Gerrymandering and the Efficiency Gap, *The University of Chicago Law Review* 82: 831-900, (2015); Chen, J. and Rodden, J., Unintentional Gerrymandering: Political Geography and Electoral Bias in Legislatures, *Quarterly Journal of Political Science* 8: 239-269, (2013); Nall, C., The Political Consequences of Spatial Policies: How Interstate Highways Facilitated Geographic Polarization, *Journal of Politics*, 77(2): 394-406, (2015); Gimple, J. and Hui, I., . Seeking politically compatible neighbors? The role of neighborhood partisan composition in residential sorting, *Political Geography* 48: 130-142 (2015); Bishop, B., *The Big Sort: Why the Clustering of Like-Minded America is Tearing Us Apart*, Houghton Mifflin Press (2008); and Jacobson, G. C., and Carson, J. L., *The Politics of Congressional Elections*, 9th ed. Lanham, MD: Rowman and Littlefield (2016).

⁴Chen, J. and Rodden, J., Unintentional Gerrymandering: Political Geography and Electoral Bias in Legislatures, *Quarterly Journal of Political Science* 8: 239-269, (2013)

Figure 1: Distribution of People and Partisan Preferences in Pennsylvania



Note: Distribution of Partisan Preferences in Pennsylvania based on the average of statewide partisan elections. Blue = Democratic, Red = Republican

voters statewide in which every precinct's vote share perfectly reflected the overall state. In other words, the party has a slight majority in every precinct that adds up to a slight majority statewide. In this case, this party's voters are extremely efficiently distributed in such a way that the party will win every single district despite only a slim majority statewide. Now imagine a different arrangement: a party that still holds a slim majority statewide, but whose voters are heavily concentrated in a few areas and sparsely populated throughout the rest of the state. In this case, despite holding a majority of votes statewide, the party will only win a few seats where their voters are heavily concentrated. The political geography of Pennsylvania closely resembles this second scenario.

The geographic concentration of a party's voters tends to harm that party when single-member districts are drawn by creating districts that favor that party by very large margins, thus “wasting” many votes by running up large majorities far beyond 50%+1.⁵

⁵McGhee, E. (2017). Measuring Efficiency in Redistricting. *Election Law Journal: Rules, Politics, and Policy*, 16(4), 417–442. doi:10.1089/elj.2017.0453

This occurs in Pennsylvania at the scale of congressional districts in the two largest cities of the state - Pittsburgh and Philadelphia. The overwhelming margins for the Democratic Party in these cities are what drives “wasted votes,” which in turn translate to fewer seats than the statewide proportion of votes would suggest.⁶

For example, Philadelphia is large enough to constitute roughly 2.1 congressional districts. Thus, a plan that attempts to avoid splitting counties will draw two districts entirely within the city of Philadelphia.⁷ In the HB2146 plan Districts 2 and 3 are completely contained in Philadelphia. In the 2020 presidential election, the city of Philadelphia supported the Democratic candidate, Joe Biden, by an 81.4% to 17.9% margin. As a result, the two congressional districts that will be contained within the city, whatever their configuration, will be overwhelmingly Democratic and contain hundreds of thousands of wasted votes that could be used more efficiently if they were geographically distributed more evenly across the state.

The story is very similar in Pittsburgh and Allegheny County as well. Pittsburgh is not large enough to contain a single congressional district. However, its population is roughly 40% of the size required for a congressional district in 2020. Allegheny County’s population is larger than a congressional district (its 2020 population was roughly equal to 1.6 congressional districts), and thus a plan that draws district boundaries that are geographically compact and avoid splitting counties and cities will contain a congressional district within Allegheny County that also contains the city of Pittsburgh. In the HB2146 plan District 15 contains the city of Pittsburgh and is entirely contained in Allegheny County. Both Pittsburgh and Allegheny County are very Democratic leaning. In the 2020 presidential election, the city supported Joe Biden by a 78% to 20.9% margin and Allegheny County supported Biden by a 59.7% to 39.2% margin. As a result, whichever congressional district Pittsburgh

⁶The term “wasted votes” in political science is not to imply that a person’s vote is not important or counted, but rather that the vote is not helpful in gaining an additional seat for their preferred party if it is an additional vote in favor of a candidate that has already won a majority of the votes in their district. Technically, all votes beyond 50%+1 are “wasted”. However, parties are interested in winning by majorities larger than 50%+1, but not by margins beyond the point at which their candidate is quite certain to win.

⁷Philadelphia city and county are coterminous.

is drawn into will be extremely Democratic as a result of the strong support for Democratic candidates in Pittsburgh and its immediate suburbs within Allegheny County.

Taken together, this suggests that any plan that follows the non-partisan criteria of drawing maps that are geographically compact and avoid splitting counties and cities will begin with three districts (2 in Philadelphia and 1 in Allegheny County centered in Pittsburgh) that are extremely Democratic leaning with an abundance of wasted votes. The spillover effect of this natural packing of Democratic voters is that the remaining 14 congressional districts will be more favorable to Republican voters than if the Democratic voters in these two large cities were more evenly distributed across the state.

The inefficient distribution of voters in Pennsylvania would not be a problem for Democrats if district boundaries were able to amble about the state and divide counties and municipalities to create districts that had less overwhelming Democratic support. Rodden (2019) notes this by saying: “Democrats would need a redistricting process that intentionally carved up large cities like pizza slices or spokes of a wheel, so as to combine some very Democratic urban neighborhoods with some Republican exurbs in an effort to spread Democrats more efficiently across districts” (pg. 155).⁸ However, the provisions governing redistricting in Pennsylvania run counter to either of these strategies. The Pennsylvania Supreme Court’s decision in *League of Women Voters of Pa. v. Commonwealth* establishes that congressional redistricting plans must adhere to traditional redistricting rules that require districts to be geographically compact and to avoid county and municipal divisions. It thus prohibits the type of meandering districts that Rodden describes above. In the end, this means that Republicans begin the redistricting process with a natural geographic advantage due to the constraints of where and how districts can be lawfully drawn combined with the particular spatial distribution of their voters.

⁸Rodden, Jonathan A. Why cities lose: The deep roots of the urban-rural political divide. Hachette UK, 2019.

4 Methods

To gauge the degree to which the HB2146 plan is a partisan gerrymander, I conduct simulated districting analyses to allow me to produce a large number of districting plans that follow traditional redistricting criteria using small geographic units as building blocks for hypothetical legislative districts. This simulation process ignores all partisan and racial considerations when drawing districts. Instead, the computer simulations are programmed to create districting plans that follow traditional districting goals without paying attention to partisanship, race, the location of incumbent legislators, or other political factors. This set of simulated districts is helpful because it provides a set of maps to which we can compare the HB2146 map that also accounts for the geographic distribution of voters. Because voters are not distributed evenly across the state (as discussed in the previous section), we cannot evaluate the fairness of a proposed plan without an apples-to-apples comparison. In other words if a plan is not evaluated against a comparison set of maps that also use the same political geography of the state, then potential issues or red flags in the map may not at all be due to partisan gerrymandering, but rather the geographic distribution of voters in the state. By comparing a proposed map to a set of alternative maps that are drawn using only non-partisan districting criteria that *also* consider the same geographic distribution of voters, we can identify if oddities or patterns in the proposed plan are due to the political geography of the state because the simulated maps are drawn *using the same political geography*. In other words, by comparing the HB2146 map to the simulated districts, we are comparing the proposal to a set of alternative maps that we know to be unbiased that holds constant the political geography of the state. If the HB2146 map produces a similar outcome as the alternative set of maps, we may reasonably conclude that the HB2146 plan is unbiased. Alternatively, if the HB2146 plan significantly diverges from the set of simulated maps, it suggests that some other criteria that were not used in drawing the comparison set of maps may have guided the decisions made in drawing the proposed map.

The process of simulating districting plans has been recognized and used in a variety

of redistricting litigation, including in Pennsylvania.⁹ While different people employ slightly different methods, the overall process is much the same. For my simulations, I use a program developed by Fifield et al. (2020).¹⁰

A significant advantage of the simulation-based approach is the ability to provide a representative sample of possible districting plans that accounts for the unique political geography of a state, such as the spatial distribution of voters or the location and number of administrative boundaries, such as counties. Simulation methods can also to a degree incorporate each state's unique redistricting rules. The simulation-based approach therefore permits us to compare a particular plan to a large number of representative districting plans in Pennsylvania. In the simulations I run, I instruct the model to generate plans that adhere to the redistricting criteria discussed in the *League of Women Voters* case: equal population, compactness, and minimizing political subdivision splits.

A major factor in the validity of the simulated maps is whether or not they constitute a representative sample of the trillions of possible maps that could be drawn.¹¹ If the sample produced by the simulations is not representative, then we may be comparing the proposed map to a biased selection of alternative maps, which renders the value of the comparison much less useful.

A specific benefit of the particular algorithm I use here is that the authors show math-

⁹See League of Women Voters of Ohio v. Ohio Redistricting Commission (2021); Harper v. Hall (2021); Common Cause v. Lewis (2019); Harper v. Lewis (2019); League of Women Voters of Pennsylvania v. Commonwealth of Pennsylvania (2018); City of Greensboro v. Guilford County Board of Elections (2017); January 6, 2022 testimony for PA LRC from Kosuke Imai and Michael Barber.

¹⁰Fifield, Benjamin, , Michael Higgins, Kosuke Imai, and Alexander Tarr. "Automated redistricting simulation using Markov chain Monte Carlo." *Journal of Computational and Graphical Statistics* 29, no. 4 (2020): 715-728.

Fifield, Benjamin, Kosuke Imai, Jun Kawahara, and Christopher T Kenny. 2020. "The essential role of empirical validation in legislative redistricting simulation." *Statistics and Public Policy* 7 (1): 52–68.

Kenny, Christopher T., Cory McCartan, Benjamin Fifield, and Kosuke Imai. 2020. *redist: Computational Algorithms for Redistricting Simulation*. <https://CRAN.R-project.org/package=redist>.

McCartan, Cory, and Kosuke Imai. 2020. "Sequential Monte Carlo for sampling balanced and compact redistricting plans." *arXiv preprint arXiv:2008.06131*.

¹¹Tam Cho, Wendy K., and Yan Y. Liu. "Toward a talismanic redistricting tool: A computational method for identifying extreme redistricting plans." *Election Law Journal* 15, no. 4 (2016): 351-366. Cho, Wendy K. Tam, and Bruce E. Cain. "Human-centered redistricting automation in the age of AI." *Science* 369, no. 6508 (2020): 1179-1181. McCartan, Cory, and Kosuke Imai. "Sequential Monte Carlo for sampling balanced and compact redistricting plans." *arXiv preprint arXiv:2008.06131* (2020).

ematically and in a small-scale validation study that their method produces a representative sample of maps. With regards to this issue, the authors state:

Yet, until recently, surprisingly few simulation algorithms have existed in the published scholarship. In fact, most of these existing studies use essentially the same Monte Carlo simulation algorithm where a geographical unit is randomly selected as a “seed” for each district and then neighboring units are added to contiguously grow this district until it reaches the pre-specified population threshold (e.g., Cirincione, Darling, and O’Rourke 2000; Chen and Rodden 2013). Unfortunately, no theoretical justification is given for these simulation algorithms, and hence they are unlikely to yield a representative sample of redistricting plans for a target population....Unlike the aforementioned standard simulation algorithms, the proposed algorithms are designed to yield a representative sample of redistricting plans under contiguity and equal population constraints.¹²

Specifically, the model is constrained to conduct 50,000 simulations in which each simulation generates 17 districts that are of roughly equal population (<0.5% deviation above or below the target population of 764,865). While congressional districts are constrained to contain a truly equal population, it is not possible to place such a strict constraint on the model. Because of this, I relax the constraint to allow for a 0.5% deviation, or a roughly 3,800 person deviation. This is common in redistricting simulations of congressional districts, including in litigation presented to, and relied upon by the Pennsylvania Supreme Court in the 2018 *League of Women Voters* case. The process for zeroing out population on any given simulation map would have minimal to no impact on the partisan outcomes.¹³

¹²Cirincione, C., Darling, T. A., and O’Rourke, T. G. (2000), “Assessing South Carolina’s 1990s Congressional Districting,” Political Geography, 19, 189–211. DOI: 10.1016/S0962-6298(99)00047-5. Chen, J., and Rodden, J. (2013), “Unintentional Gerrymandering: Political Geography and Electoral Bias in Legislatures,” Quarterly Journal of Political Science, 8, 239–269. DOI: 10.1561/100.00012033.

¹³See for example: Expert report of Dr. Wesley Pegden in League of Women Voters of Pennsylvania case, whose simulations use a 2% population constraint. Expert report of Dr. Jonathan Mattingly in *Harper v. Hall* in North Carolina, whose congressional simulations use a 1% population constraint and states, “We have verified in previous work in related settings that the small changes needed to make the districting plan

The algorithm generates 17 congressional districts with each run by assembling small geographic units — electoral precincts — into larger groups until a group of precincts is large enough to constitute a new legislative district. It then repeats this process 50,000 times, generating a different set of 17 districts with each run of the model. In each of the 50,000 iterations, the model is instructed to generate geographically compact districts that do not divide cities, boroughs, townships, and other municipal corporations. No city in Pennsylvania is larger than a congressional district aside from Philadelphia. As a result, there are no split precincts or municipalities (aside from the necessity of dividing Philadelphia into multiple districts due to its population) in the simulated districts. I constrain the model to not split municipalities because of the constitutional instructions in Article II, Section 16 that no city, incorporated town, borough, township or ward shall be divided unless “absolutely necessary”. Although Article II Section 16 does not on its face apply to congressional redistricting, the *League of Women Voters* case held that an “essential part” of an inquiry into whether a congressional plan is constitution under the Free and Equal Elections Clause is if the districts created under the plan are: “composed of compact and contiguous territory; as nearly equal in population as practicable; and which do not divide any county, city, incorporated town, borough, township, or ward, except where necessary to ensure equality of population” (645 Pa. 1, 123, 2018). Later, the court described this principle as the “minimization of the division of political subdivisions” (Id). Thus, if it is possible to generate districts that do not split municipalities and stay within the 0.5% population constraint, it is therefore not “absolutely necessary” to split municipalities aside from Philadelphia when constructing simulated districts. The process for zeroing out population on any given simulation map would, of course, require the division of some municipal corporations, but not many. The model is also instructed to draw districts that cross county boundaries as few times as have perfectly balanced populations do not change the results.” See also expert report of Daniel Magleby in *Harper v. Hall* in North Carolina. Also, expert report of Kouske Imai in *League of Women Voters of Ohio v. Ohio Redistricting Commission*, who uses a 0.5% population deviation and states, “Although this deviation is greater than the population deviation used in the enacted plan, it only accounts for less than 4,000 people and hence has no impact on the conclusions of my analysis.”

possible. County populations do not always add up to round units of districts, and thus some county boundaries will be need to be traversed. The model is further instructed that when a county boundary needs to be crossed, it should avoid splitting the county more times than necessary.

Once the simulated district plans are complete, only then do I compute the partisan composition of each district in each plan. For the partisan composition of each district I rely on the election results from statewide elections disaggregated to the level of the election precinct. I then reassemble these election results for each of the simulated districts in each of the 50,000 simulations to compute the proportion of votes across all statewide elections conducted between 2012 and 2020 that were won by the Democratic and Republican candidates in those districts.¹⁴ In other words, the partisan index is the average vote share for Democratic candidates in each district for the statewide elections considered between 2012-2020. I choose the period 2012-2020 because it represents an entire decade of elections between decennial censuses when redistricting traditionally occurs. Averages of multiple elections have the benefit of “washing out” the impact of any particular election, since individual elections can vary due to particular idiosyncratic candidate features. Furthermore, particular years can vary due to national electoral waves (i.e. 2018 was an especially good year for Democrats while 2016 was an especially good year for Republicans nationwide). Later in the report I also display the results using a variety of alternative election indices.

¹⁴The particular races are 2020: President, Auditor, Attorney General, Treasurer; 2018: Governor, US Senate; 2016: President, US Senate, Auditor, Attorney General, Treasurer; 2014. I do not include statewide judicial elections in the index. It is uncommon in political science to use judicial elections to measure voters' partisan preferences as research suggests voters treat judicial elections very differently, even when judges run under party labels, than they do partisan elections to legislative and executive positions. Other commonly used measures indices such as Dave's Redistricting and PlanScore.com also omit judicial elections from their partisan indices.

5 Results

5.1 Population, Boundary Splits, and Compactness

Table 1 below compares the HB2146 plan to the distribution of simulations for boundary splits, and compactness. The HB2146 plan splits 15 counties, which is within the range of county splits in the simulations. The HB2146 plan divides only 16 municipalities, one of which would be Philadelphia, which is required to be divided because the city's population is larger than a single congressional district. Furthermore, the requirement that the proposal contain exact population equality will require the division of some municipalities since the combination of cities into districts will not necessarily lead to the exact population needed for a congressional district. Finally, the HB2146 plan has only nine precinct splits. On the whole, the plan performs exceptionally well at having few county, municipal, and precinct splits. With regards to district compactness, the HB2146 plan's average district compactness score closely aligns with the results of the simulations. District-by-district measures of compactness as well as a list of specific counties and municipalities that are split are contained in the appendix of this report.

Table 1: HB2146 plan and 50,000 Simulations: Subdivision Splits, and Compactness

	HB2146 plan	Simulations Median	Simulations Range
Boundary Splits			
Counties Split:	15	12	[7, 15]
Municipalities Split:	16	1	[1, 1]
Precincts Split:	9	0	[0, 0]
Compactness			
Average Polsby-Popper:	0.32	0.28	[0.22, 0.35]

Note: As described above, the simulations are constrained to not divide municipalities, aside from Philadelphia, which is too large to be contained within one district. However, exact population equality requires some municipalities be split in the proposed plan.

5.2 Partisan Lean of Districts

Before comparing the proposal to the simulations, I first present the results of the partisan index for each district in the HB2146 plan. Figure 2 shows this for the 17 districts in the plan. Districts are ordered from least Democratic at the bottom to most Democratic at the top. Districts with a partisan index less than 0.50 are Republican leaning and districts with a partisan index greater than 0.50 are Democratic leaning. A vertical dashed line is placed at 0.50 for reference. In the plan there are eight Republican-leaning districts with an index less than 0.50 (on the left side of the dashed line at .50) and nine Democratic-leaning districts with an index greater than 0.50 (on the right side of the dashed line at .50). The grey horizontal lines around each point show the range of election outcomes for all of the statewide elections used to generate the index. Districts in which the Republican candidate for statewide elections won the majority of the two-party vote share in all of the statewide races in that district are shown as red squares while districts where the Democratic candidate for statewide elections won the majority of the two-party vote share in all of the statewide races in that district are shown as blue triangles. Districts where both parties have won a majority of the two-party vote share in these statewide races in the district are displayed as green circles. Looking at the range across the index, there are six districts colored red (reliably Republican), five blue districts (reliable Democratic), and six green districts (competitive) in the plan. Using an alternative definition of competitiveness based on the closeness of the index to 0.50, there are five districts with an index between 0.48 and 0.52. A range of two percentage points is a commonly used measure of competitiveness in congressional elections.

A few key points come out of this figure. First, we see the result of the natural clustering of Democratic voters in Philadelphia and Pittsburgh. Districts 3 and 2 are the most Democratic leaning and are entirely contained within Philadelphia in the HB2146 plan. District 15 is the third most Democratic leaning district and contains the entirety of Pittsburgh and some of its surrounding suburbs in Allegheny County. These districts are

overwhelmingly Democratic leaning. In fact, they are much more Democratic than the degree to which the most Republican-leaning districts lean towards Republicans. For example, the most Democratic district (District 3) has a partisan index of 0.92 while the most Republican district (District 13) has a partisan index of 0.35 (0.35 is much closer to .50 than 0.92 is to 0.50). This illustrates the idea that geographic clustering of voters when divided into single member districts that are compact and avoid dividing counties and cities generally lead to more wasted votes for Democrats than for Republicans.

The second major point is that the HB2146 plan generates a significant number of competitive districts. Electoral competitiveness is an essential component of a liberal democracy. The threat of electoral defeat is critical to creating a democratic government in which elected officials are responsive to public opinion and are held accountable for their decisions while in office.¹⁵

I use two different metrics to measure competitiveness.

The first measure considers a district competitive if both a Democratic and Republican candidate for statewide federal office between 2012-2020 have won a majority of the two-party vote share in that district. Figure 2 shows these districts as green circles. Note how the grey line in each of these districts crosses the 0.50 line, indicating that both Republican and Democratic candidates for statewide office have won a majority of votes in that district. This approach has the virtue of considering the candidate-specific characteristics that a partisan average or index would not measure. For example, particular candidates from either party might outperform their party's average candidate performance. This is important to consider because actual elections are determined by which candidate wins the most votes, not the result of an average of votes cast, and individual elections in individual

¹⁵Mayhew, David R., 1974. *Congress: The Electoral Connection*. New Haven, CT: Yale University Press. Gordon, Sanford C., and Gregory Huber. "The effect of electoral competitiveness on incumbent behavior." *Quarterly Journal of Political Science* 2, no. 2 (2007): 107-138.

Ansolabehere, Stephen, David Brady, and Morris Fiorina. "The vanishing marginals and electoral responsiveness." *British Journal of Political Science* 22, no. 1 (1992): 21-38.

Dropp, Kyle, and Zachary Peskowitz. "Electoral security and the provision of constituency service." *The Journal of Politics* 74, no. 1 (2012): 220-234.

districts are influenced by the characteristics and qualities of individual candidates. Using this metric, there are 6 competitive districts (Districts 16, 8, 17, 7, 6, and 1).

The second measure of competitiveness uses the partisan index and simply looks at districts where the partisan index is within two percentage points of 50% of the two-party vote share. Scholars have often used two percentage points as a heuristic for hyper-close races in which unforeseen or “knife-edge electoral shifts” can change election results.¹⁶ Furthermore, recent studies of the legislative incumbency advantage have suggested a decline in the benefit afforded to incumbents by voters with more recent estimates being between 3 and 4 percentage points, which divided symmetrically would yield roughly 2 points on either side of the 50% vote margin.¹⁷ Using this metric, there are five competitive districts (Districts 8, 17, 7, 6, and 1).

Unlike the first metric described above, this measure of competitiveness is based on the average performance of candidates. Both metrics have their benefits and drawbacks. The virtue of using the average is that it “washes out” the impact of any one particular candidate by aggregating multiple election results together. The virtue of the “bipartisan victories” metric described above is that it captures the fact that particular candidates often perform very differently from what a partisan index would predict. Thus, the virtues of the first are in many ways the drawbacks of the second, and vice versa. As a result, including both presents a more complete picture. In either case, the HB2146 plan creates a substantial number of competitive districts.

A final point to note is that among these competitive districts, four of them lean Democratic. In other words, while both parties will likely win these districts some of the time, Democratic candidates are slightly favored in four of the five (or six depending on the measure of competitiveness) competitive districts in the plan.

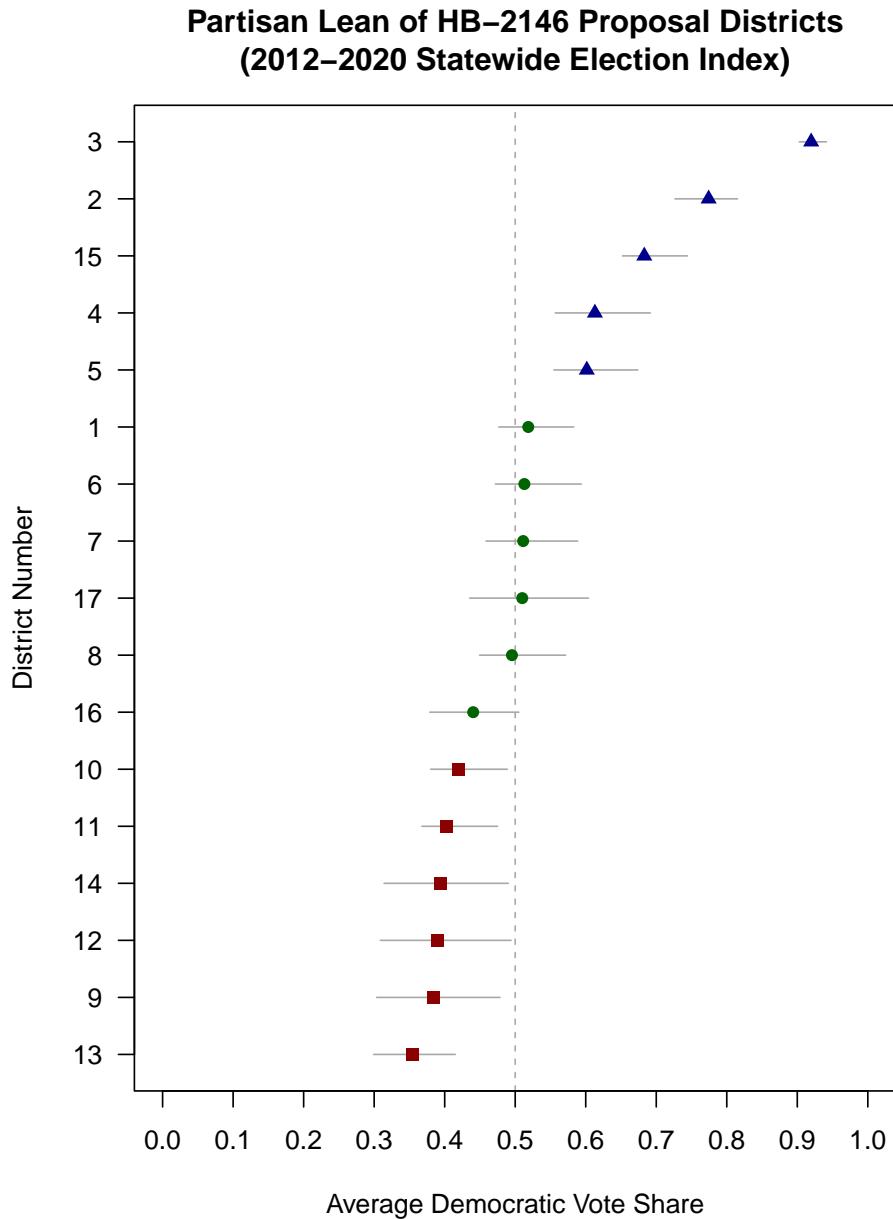
It is important to note that partisan averages — such as the ones I have created here

¹⁶Erikson, Robert S., and Rocío Titiunik. “Using regression discontinuity to uncover the personal incumbency advantage.” *Quarterly Journal of Political Science* 10, no. 1 (2015): 101-119.

¹⁷Jacobson, Gary C. “It’s nothing personal: The decline of the incumbency advantage in US House elections.” *The Journal of Politics* 77, no. 3 (2015): 861-873.

— are useful, but not perfect. Every congressional race is different. Individual candidate factors such as prior elected experience, professional background, gender, and ties to the local community are all important factors in determining candidate success. Campaigns and the issues and policies that candidates choose to emphasize and endorse are also important. These factors all contribute to making each race unique and slightly different from what an index of statewide election results might predict. In other words, no election will perfectly mirror the partisan average for that district based on an index of election results, and in some cases that difference could be quite large.

Figure 2: Partisan Index of HB2146 plan Congressional Districts



Note: Partisan Index based on the average of statewide partisan races between 2012–2020. Districts with a partisan index less than 0.50 are Republican leaning and districts with a partisan index greater than 0.50 are Democratic leaning. A vertical dashed line is placed at 0.50 for reference. The grey horizontal lines around each point show the range of election outcomes for all of the statewide elections used to generate the index. Districts in which the Republican candidate for statewide elections won the majority of the two-party vote share in all of the statewide races are shown as red triangles (there are 6 of them) while districts where the Democratic candidate for statewide elections won the majority of the two-party vote share in all of the statewide races are shown as blue triangles (there are 5 of them). Districts where both parties have won a majority of the two-party vote share in these statewide races are displayed as green circles (there are 6 of them).

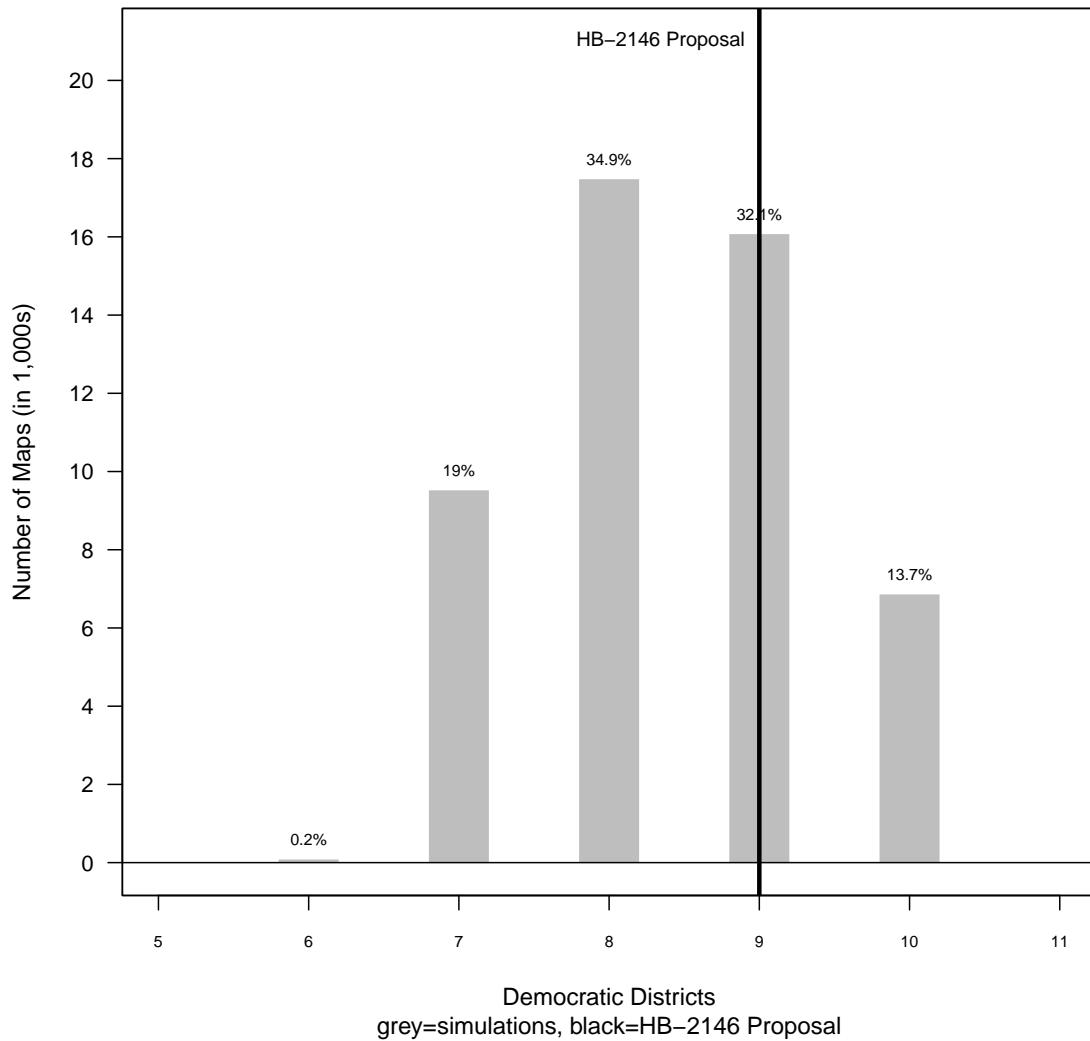
5.3 Partisan Lean of Districts Compared to Simulations

Figure 3 displays the distribution of Democratic-leaning districts in both the simulations and the HB2146 plan using the 2012-2020 partisan index discussed above. If a district in the simulations or in the HB2146 plan has a partisan index greater than 0.50, I call that a Democratic-leaning district. Likewise, if a district in the simulations has a partisan index less than 0.50, I call that a Republican-leaning district. The grey histogram shows the distribution of Democratic-leaning seats generated by the simulations. The simulations generate between six and ten Democratic-leaning districts, and the numbers above each bar in the histogram display the proportion of simulated maps that generate each outcome. For example, in 34.9% of the simulations there are eight Democratic-leaning districts (and therefore nine Republican-leaning districts). The solid black vertical line shows the results of calculating the partisan index for the HB2146 plan. The HB2146 plan generates nine Democratic leaning districts, which is in line with the distribution of Democratic-leaning seats generated by the simulations (32.1% of the simulations generate this result). As noted above, the most common outcome in the simulations is eight Democratic-leaning seats, which is one less than the HB2146 plan generates.

Recall that in using the simulations we are comparing the proposed map to a set of maps drawn by the computer using only those criteria that I instructed the algorithm to follow - namely the pre-specified nonpartisan criteria of equal population, contiguity, geographic compactness and a preference for fewer county splits. Both the HB2146 plan and the simulations account for the unique political geography of Pennsylvania. Doing so shows us that the HB2146 plan is within the middle portion of simulation results and if anything leans slightly towards the Democratic party by generating nine Democratic-leaning districts rather than eight, which is the modal outcome in the simulations. By no standard definition would the plan be considered an outlier.

Figure 3: Partisan Composition of HB2146 plan and Simulations

**Comparison to 50,000 simulated PA congressional plans:
(drawn with population equality, compactness, and minimal county splits)**



Note: The grey distribution is the number of Democratic seats generated from the 50,000 simulations. The vertical black line is the number of Democratic leaning seats in the HB2146 plan. The HB2146 plan generates 9 Democratic leaning districts. The partisan lean of districts in the simulations and the HB2146 plan are calculated as the two-party vote share of statewide partisan elections from 2012-2020.

5.4 District-by-District Comparisons

While Figure 3 shows the position of the HB2146 plan in relation to the simulations overall, it is also instructive to look at a district-by-district level to see if any particular district stands out as an outlier. Figure 4 below does this for each of the 17 districts in

the state. The figure plots the partisan lean of each district across all of the simulations ordered from least Democratic at the top to most Democratic at the bottom of the figure. The simulation results are displayed in grey and generate a “cloud” or range of partisan outcomes for each district. The black dots in the figure show the partisan lean of each of the districts in the HB2146 plan and their relative position within the simulations. Next to each district is text showing the position of the HB2146 plan in relation to the simulations. For example, in the most Republican-leaning district (District 13) at the top of the figure, the HB2146 plan is more Democratic than 64% of the simulations in that district.

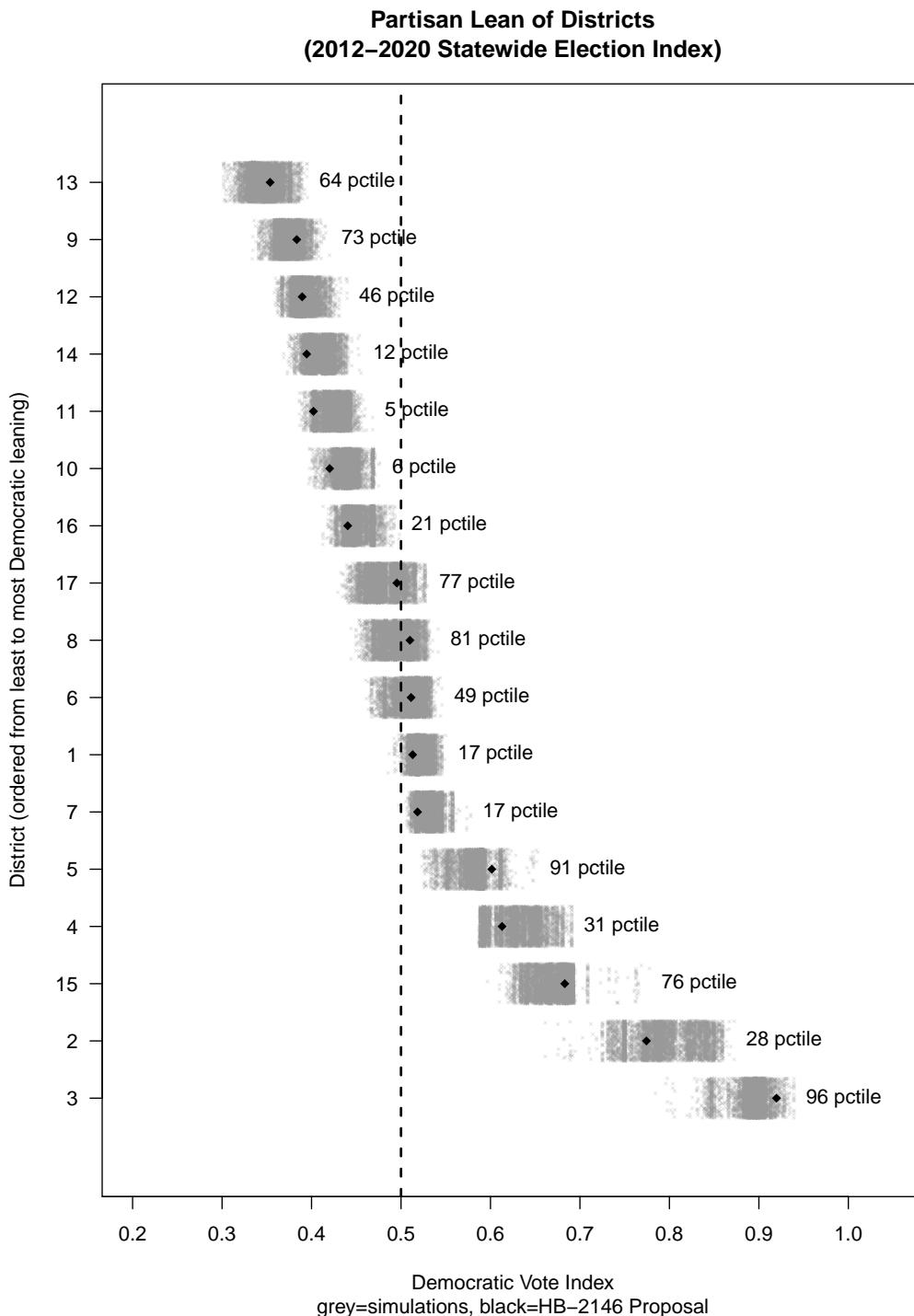
Looking district by district, we see that in most cases the HB2146 plan sits well within the middle of the distribution of simulations. In a few cases it stands out as an outlier, and I consider each of these cases one by one. In the 5th and 6th most Republican districts (Districts 11 and 10 in the HB2146 plan, as labelled on the vertical axis of the figure) the HB2146 plan is at the Republican edge of the simulation results indicating that the HB2146 plan is more Republican than only five and six percent of the simulations in these two districts, respectively. However, both of these districts are squarely Republican leaning, even in the simulations that are more favorable to Democrats.

In the 5th most Republican district (District 11 in the HB2146 plan) the partisan index of the HB2146 plan is 0.40 while the median simulation has a partisan index of 0.42. In other words, District 11 is only two points away from the median simulation in this district, and a partisan index of 0.40 or 0.42 would be a safely Republican districts in either case.

The same is true of the 6th most Republican district in the simulations, which is District 10 in the HB2146 plan. This district has a partisan index of 0.42 in the HB2146 plan while the median simulation has a partisan index of 0.435. In other words, District 10 is only 1.5 percentage points away from the median simulation in this district, and a partisan index of 0.42 or 0.435 would be a safely Republican districts in either case. In other words, in these two districts, the position of the HB2146 plan in relation to the median simulation will have minimal real-world impact on the electoral outcomes in those districts.

As described above, the HB2146 plan produces five districts that are extremely competitive with a partisan index within two percentage points of 0.50 (Districts 17, 8, 6, 1, and 7). In two of those five districts, the proposal is more Democratic than the median partisan index in the simulations (Districts 17 and 8), is very near the median simulation in one of the districts (District 6), and in two of these districts (Districts 1 and 7) the HB2146 plan is more Republican than the median simulation. Thus, in the districts where a shift of a few percentage points really could make a difference in the party that wins a congressional seat, the HB2146 plan is balanced between favoring Democrats in 2 of the districts, Republicans in 2 of the districts, and neither party in 1 of the districts when compared to the distribution of simulation results.

Figure 4: Partisan Composition of HB2146 plan and Simulations



Note: The grey ‘clusters’ show the range of vote margins for each district, ordered from least Democratic to most Democratic in the 50,000 simulations. The black dot inside of each cluster shows the partisan index for the HB2146 plan. Next to each cluster is the percentile, or relative position of the HB2146 plan within each cluster of simulation results for each district.

5.5 Median-Mean Difference

Another common measure of the partisan slant of a districting plan is the median-mean difference.¹⁸ The median-mean measure is calculated by taking the median value of the partisan index across all 17 districts in a plan (the value for which half of the observations are smaller and half the observations are larger) and subtracting from that the mean partisan index (the simple average) of all of the districts from the median. Consider a simple example in which there are three districts in a plan with partisan indices of 0.91, 0.46, and 0.40. To find the median we simply look for the district for which there is one district larger and one district smaller (0.46 in this case). To find the mean, we simply take the average by dividing the sum of the partisan indices by the number of districts. In this case, $(0.91+0.46+0.40)/3 = 0.59$. The median-mean value would then be $0.46-0.59 = -0.13$. As in this example, in Figure 5 I take the Democratic vote share of the median district minus the mean Democratic vote share for all 17 districts in the HB2146 plan. Negative numbers indicate a districting plan that favors Republicans and positive numbers indicate a slant in favor of Democrats.

The median-mean test is essentially a test of skew, or in the context of redistricting packing voters into legislative districts. If voters of one party are packed into few districts, those districts will have very high vote shares for one party and will pull the value of the mean district partisanship away from the district partisan index of the median district.¹⁹ This indicates that the party that is packed into the districts with overwhelming majorities will have a harder time translating their votes into seats.²⁰

¹⁸See Best, Robin E., Shawn J. Donahue, Jonathan Krasno, Daniel B. Magleby, and Michael D. McDonald. "Considering the prospects for establishing a packing gerrymandering standard." *Election Law Journal* 17, no. 1 (2018): 1-20. Warrington, Gregory S. "A comparison of partisan-gerrymandering measures." *Election Law Journal: Rules, Politics, and Policy* 18, no. 3 (2019): 262-281. Wang, Samuel S-H. "Three tests for practical evaluation of partisan gerrymandering." *Stan. L. Rev.* 68 (2016): 1263. McDonald, Michael D., and Robin E. Best. "Unfair partisan gerrymanders in politics and law: A diagnostic applied to six cases." *Election Law Journal* 14, no. 4 (2015): 312-330.

¹⁹A helpful analogy is to imagine a representative group of 100 Americans gathered at a restaurant. The median and mean incomes of the 100 customers are likely quite similar. If Bill Gates walks into the restaurant, the median income of the now 101 patrons will not shift by much at all, but the mean income will jump significantly, possibly by several million dollars.

²⁰McDonald, Michael D., and Robin E. Best. "Unfair partisan gerrymanders in politics and law: A diagnostic applied to six cases." *Election Law Journal* 14, no. 4 (2015): 312-330.

One drawback of the median-mean test is that it does not account for the natural clustering of voters that occurs in Pennsylvania and other states. This can be remedied by also computing the median-mean difference for the simulated districting plans that also consider for the geographic distribution of voters in the state. This allows us to make an apples-to-apples comparison that holds the political geography of the state constant. Figure 5 displays the results of the median-mean measure for the simulations (in grey) and the HB2146 plan (solid black line). The fact that the distribution of results from the simulations is mostly less than zero shows that the geography of Pennsylvania leads to a natural advantage for Republicans due to the dense clustering of Democratic voters in Philadelphia and Pittsburgh even when districts are drawn using strictly non-partisan criteria.

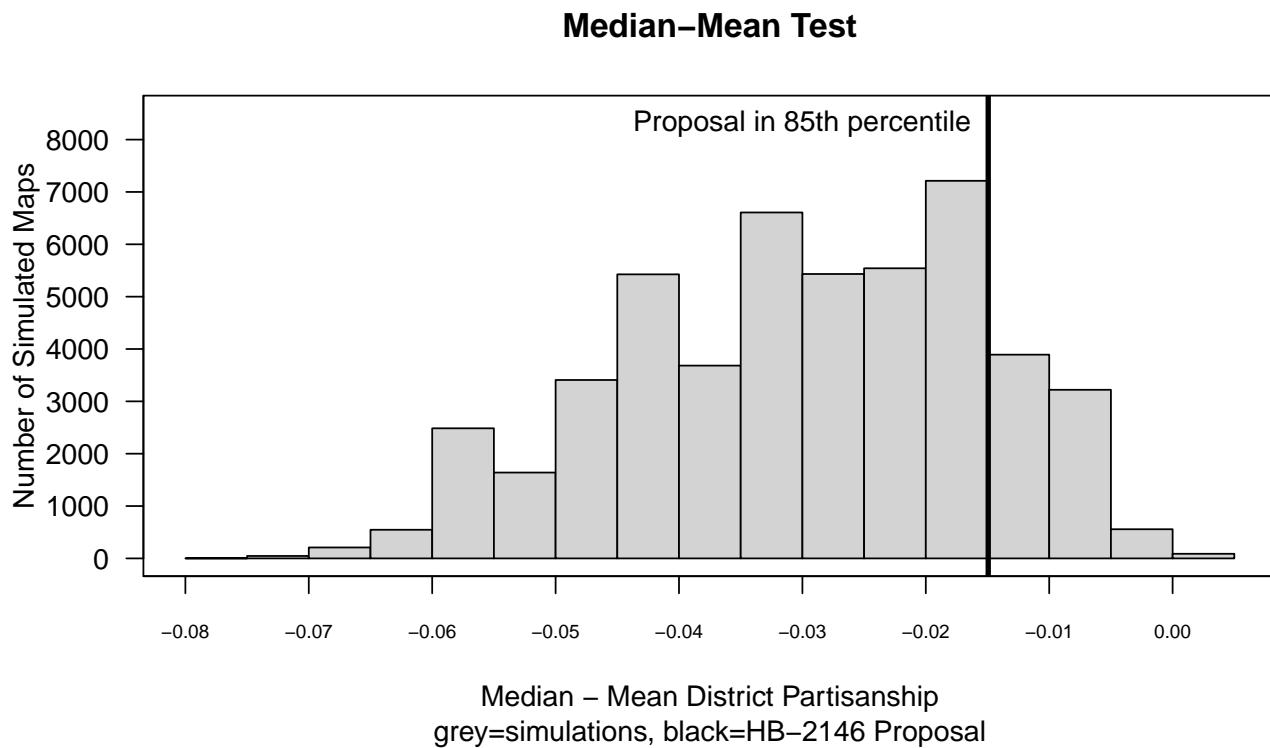
The solid black line shows the results of the HB2146 plan. There are two major points to take away from the results. First, without comparing to the simulations, the HB2146 plan is very nearly unbiased. The median-mean value for the HB2146 plan is -0.015, which is very close to zero.²¹ In other words, the median district and the mean district in the HB2146 plan are different by less than two percentage points. Second, when comparing the HB2146 plan to the simulations, the HB2146 plan is more favorable to Democratic voters than the vast majority of the simulated districting plans. The HB2146 plan has a median-mean value that is smaller (in absolute value) than 85 percent of the simulated plans. In other words, using only the non-partisan criteria described above to draw the simulated districts, 85% of them generate districts with a greater median-mean value, indicating a less efficient distribution of Democratic voters than the HB2146 plan contains.

5.6 Efficiency Gap

The efficiency gap is another common redistricting metric and is similar to the median-mean measure in that it looks for the degree to which a party's votes statewide are translated

²¹For example, the congressional plan that was challenged in the *League of Women Voters of Pennsylvania* case in 2017-2018 showed the congressional district plan had a median-mean difference of -0.059. The post-LWV case 2020 congressional plan had a median-mean difference of tktk.

Figure 5: Median-Mean Measure of HB2146 plan and Simulations



Note: Values calculated by taking the Democratic partisan index of the median district minus the mean of all 17 districts' partisan indices. Negative numbers indicate a districting plan that favors Republicans and positive numbers indicate a slant in favor of Democrats. The grey histogram shows the results for each of the simulations. The black bar shows the results for the HB2146 plan. The proposal shows very little absolute bias (it is very close to zero) and is more favorable to Democrats than 85% of the simulated districts.

into seats in each district.²² A description of this measure provided by the Brennan Center for Justice summarizes it well: “[T]he efficiency gap counts the number of votes each party wastes in an election to determine whether either party enjoyed a systematic advantage in turning votes into seats. Any vote cast for a losing candidate is considered wasted, as are all the votes cast for a winning candidate in excess of the number needed to win.”²³ In other words, the ideal strategy for a political to maximize the impact of their voters is to distribute

²²McGhee, Eric. "Measuring efficiency in redistricting." *Election Law Journal: Rules, Politics, and Policy* 16, no. 4 (2017): 417-442. Veomett, Ellen. "Efficiency gap, voter turnout, and the efficiency principle." *Election Law Journal: Rules, Politics, and Policy* 17, no. 4 (2018): 249-263. Plener Cover, Benjamin. "Quantifying partisan gerrymandering: An evaluation of the efficiency gap proposal." *Stan. L. Rev.* 70 (2018): 1131.

²³https://www.brennancenter.org/sites/default/files/legal-work/How_the_Efficiency_Gap_Standard_Works.pdf

them as evenly as possible across districts so as to win by a narrow margin in the district they win and lose by very large margins in the districts where they lose. Put another way, ‘win by a little, lose by a lot’ is the ideal strategy for a party to maximize their impact of their voters.²⁴

The Brennan Center provides a simple example of how the efficiency gap is calculated:

To understand how the efficiency gap works, consider a hypothetical state with 500 residents that is divided into five legislative districts, each with 100 voters. In the most recent election cycle, Democrats won Districts 1 and 2 by wide margins, while Republicans won Districts 3, 4, and 5 in closer races. Overall, Democratic candidates received 55 percent of the statewide vote but won just 40 percent of the legislative seats, while Republican candidates received 45 percent and won 60 percent of the seats. The table below shows the election results for each district.²⁵

District	D votes	R Votes	Result
1	75	25	D wins
2	60	40	D wins
3	43	57	R wins
4	48	52	R wins
5	49	51	R wins
Total:	275	225	

Once we have the election results, the first step is to consider the number of “wasted votes” in each district. Because the Republican candidate in this example lost in District 1, all 25 of the votes cast for that candidate are wasted. The Democratic candidate in District 1 won, but by 24 more votes than would be necessary (since all that is needed is 51 votes to win). Thus, there are 24 wasted Democratic votes in this district. Taking the difference indicates that there was a net of 1 Republican wasted vote in this district.

²⁴Of course, parties have other priorities and winning by a single vote might not be their ideal scenario in reality.

²⁵https://www.brennancenter.org/sites/default/files/legal-work/How_the_Efficiency_Gap_Standard_Works.pdf

The efficiency gap is then calculated as Efficiency Gap = (Total Democratic Wasted Votes - Total Republican Wasted Votes) / Total Votes. In order to account for uneven turnout across districts and elections, the efficiency gap formula can be re-expressed as the following equation: Efficiency Gap = (Seat Margin - 50%) - 2(Vote Margin - 50%) where the seat margin is the fraction of seats won by Democrats minus 0.50 and the vote margin is the fraction of votes won by Democratic candidates statewide minus 0.50.²⁶

In this example and in Figure 5 I use the Democratic seat and vote margins which means that negative efficiency gap numbers indicate a districting plan that favors Republican voters and positive numbers indicate a plan that favors Democratic voters. As with the median-mean test, the efficiency gap has the drawback of not accounting for the natural clustering of Democratic voters in Pennsylvania and other states. However, as before I remedy this by also computing the efficiency gap for the simulated districting plans that also must account for the geographic distribution of voters in the state. This allows us to make an apples-to-apples comparison that accounts for political geography. Figure 6 displays the results of the efficiency-gap measure for the simulations (in grey) and the HB2146 plan (solid black line). The distribution of results from the simulations show that the geography of Pennsylvania leads to a naturally arising advantage for Republicans due to the dense clustering of Democratic voters in Philadelphia and Pittsburgh.²⁷

The solid black line shows the results of the HB2146 plan. There are two major points to take away from the results. First, the HB2146 plan is very nearly unbiased. The efficiency gap for the HB2146 plan is -0.02, which is very close to zero.²⁸ In other words, in the HB2146 plan Democratic votes are not much more likely than Republican votes to be “wasted” across the districts. Second, when comparing the HB2146 plan to the simulations, the HB2146

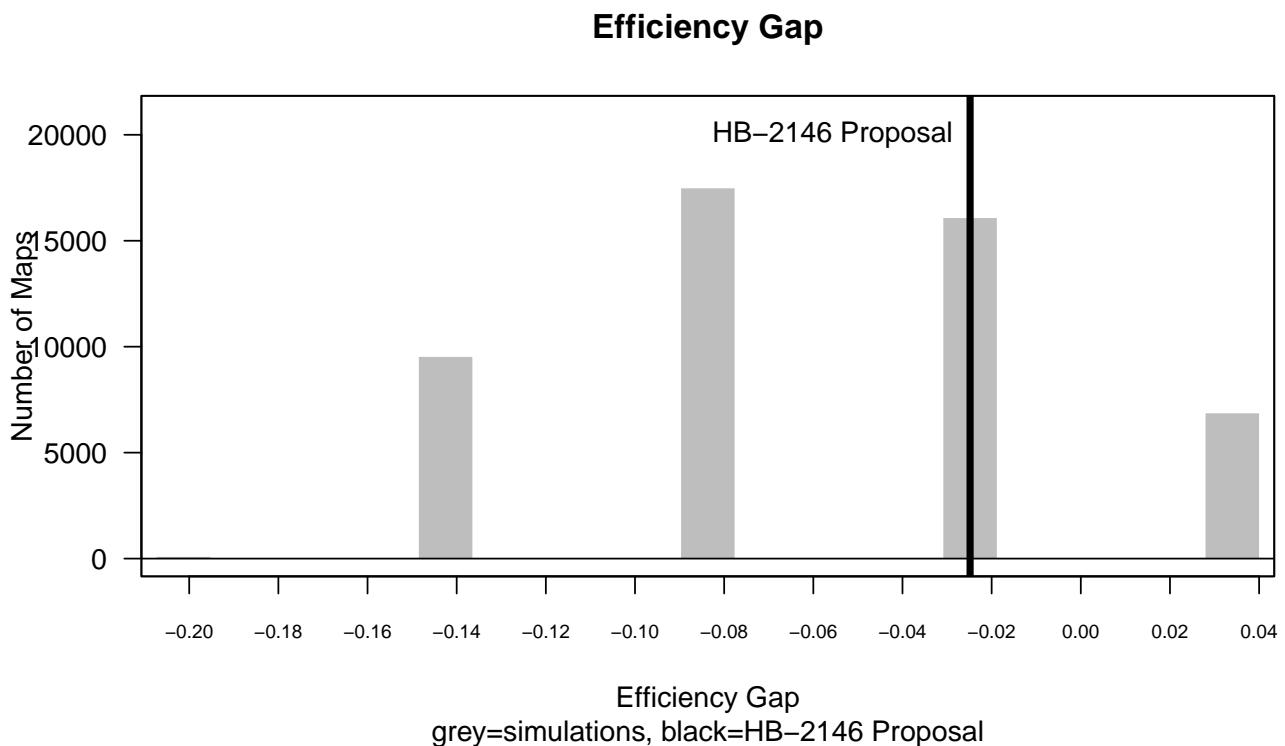
²⁶See McGhee, Eric. "Measuring efficiency in redistricting." *Election Law Journal: Rules, Politics, and Policy* 16, no. 4 (2017): 417-442.

²⁷Because the efficiency gap is a measure of seat shares, it will be a ‘chunky’ measure with values for each seat won or lost in a plan, unlike the median-mean measure which is a more continuous measure that changes based on small changes in the margin of victory in each district.

²⁸For example, the congressional plan that was challenged in the *League of Women Voters of Pennsylvania* case in 2018 showed the congressional district plan had a pro-Republican efficiency gap of between -0.15 and -0.20. The post-LWV 2020 congressional map had an efficiency gap of tktk.

plan is more favorable to Democratic voters than the majority of the simulated districting plans. The HB2146 plan has an efficiency gap that is smaller (in absolute value) than all other outcomes in the simulated plans. While some of the simulated plans generate pro-Democratic efficiency gaps, they are larger in absolute terms and would be more biased than the HB2146 plan in favor of Democrats instead of the very slight lean towards Republicans exhibited in the HB2146 plan. In other words, using only the non-partisan criteria described above to draw the simulated districts, the HB2146 plan is in agreement with the least biased outcome in the simulations.

Figure 6: Efficiency Gap Measure of HB2146 plan and Simulations



Note: Distribution of efficiency gap among simulations shown in grey and the HB2146 plan shown as the solid black line. Negative values indicate plans that have a Republican advantage and positive values indicate plans that have a Democratic advantage. The HB2146 plan has a very small efficiency gap of -0.02 and is more favorable to Democratic voters than the majority of the non-partisan simulations, which have larger (more negative) efficiency gap values.

5.7 Expected Seats from Uniform Swing

Another measure of redistricting considers how a plan performs, on average, under a variety of different electoral environments. While the partisan index does this to a degree by averaging across a number of elections and years, I present another measure here where I report the results of applying a randomly chosen uniform swing to the election results in the HB2146 plan and the simulations. A uniform swing is simply a way of asking what would the election results in the districts look like if a certain percentage were added uniformly to each district in the plan.²⁹ In other words, a uniform swing of 1.3 points in the Democratic direction would simply add 0.013 to the partisan index of each district while a uniform swing of 2.5 points in the Republican direction would simply subtract 0.025 from the partisan index of each district. Of course, a swing of 1 points is more likely than a swing of 5 or 6 points as large wave elections are more rare than elections that perform closer to the average performance of each party. To account for this, I randomly apply 10,000 uniform swings to the simulations and the partisan index of the HB2146 plan and calculate the average of the number of seats that are held by Democrats in the HB2146 plan and each of the 50,000 simulations. The value of the uniform swing is chosen from a normal distribution that is centered at zero with a standard deviation of 3 percentage points.³⁰ Thus, small swings are more likely than large swings, but large swings of 3, 4, 5, and even 6 percentage points are possible, just as we occasionally observe large electoral waves in national politics. This gives us an idea of how a plan performs, on average, under a variety of potential electoral environments.

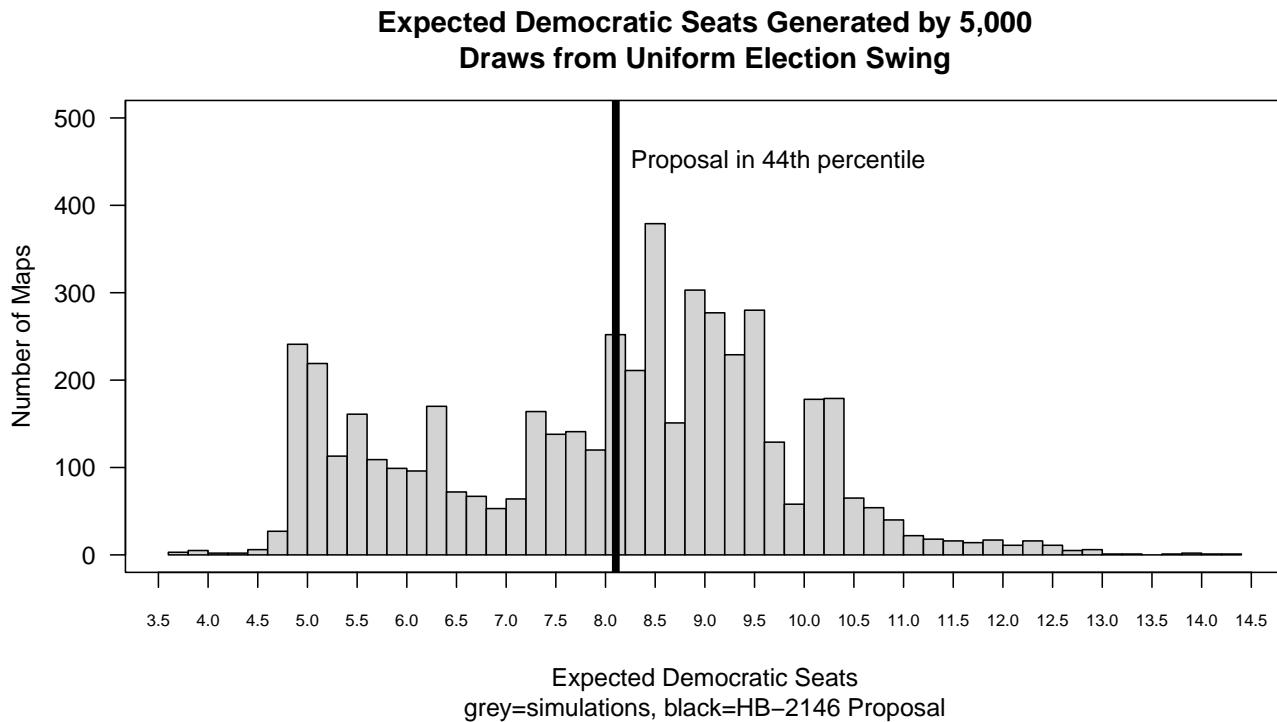
The result of this process is a measure of the expected number of Democratic seats that a plan will produce under a variety of different electoral conditions — some good for

²⁹See Jackman, Simon. "The predictive power of uniform swing." *PS: Political Science & Politics* 47, no. 2 (2014): 317-321 for a discussion of the concept of a uniform swing in elections. See Expert Report of Dr. Wesley Pegden in *Harper v. Hall*, Wake County North Carolina, No. 21 CVS 500085 for another example of using a uniform swing to calculate expected seat shares in redistricting.

³⁰3 percentage points is approximately the standard deviation of all of the statewide election results used in creating the 2012-2020 partisan index.

one party, some good for the other party, and some that are about average for both parties. Figure 7 shows the results of this process. The grey distribution shows the expected number of Democratic seats after applying the 5,000 draws from the uniform swing to the 50,000 simulations. Some of the simulated plans are very favorable to Republicans (with expected Democratic seat shares near 5) while other plans are very favorable to Democrats (with expected seat shares of 12 Democratic seats). The HB2146 plan, however, is nearly exactly in the middle of this distribution. The proposal generates an expected seats of 8.10 and is in the 44th percentile of the distribution of the simulated results. In other words, 44 percent of the simulations are worse for Democrats and 55 percent the simulations are better for Democrats compared to the HB2146 plan. The plan is positioned nearly in the middle of the non-partisan simulations on this measure.

Figure 7: Expected Seats from Uniform Swing of HB2146 plan and Simulations



Note: Distribution of expected seats in the HB2146 plan (black line) and the simulations (grey distribution) after applying 5,000 uniform swings to the partisan index. The value of each uniform swing is chosen from a normal distribution that is centered at zero with a standard deviation of 3 percentage points.

5.8 Considerations of Race

Table 3 shows the non-Hispanic Black voting age population percent of each district and the non-White voting age population percent of each district in the HB2146 plan. The districts are ordered from lowest to highest percentage in each category. The HB2146 plan contains one district (District 3) in Philadelphia that is just shy of being majority Black with a 49.82% non-Hispanic Black voting age population. Additionally, District 2 has a 59.60% non-White voting age population. District 15 has a 32.5% non-White voting age population.

Table 2: District-by-District Racial Composition of HB2146 plan

District rank	District Number	NHBVAP	District Number	Non-White
17	12	2.1%	14	7.2%
16	9	2.3%	12	9.0%
15	14	2.4%	16	10.8%
14	11	3.3%	9	11.6%
13	1	3.8%	17	12.2%
12	17	3.9%	13	13.8%
11	16	3.9%	1	18.1%
10	13	4.9%	11	18.1%
9	7	5.2%	8	18.3%
8	6	5.3%	10	20.0%
7	8	5.4%	4	25.6%
6	10	6.8%	6	26.4%
5	4	9.6%	7	27.5%
4	15	17.5%	15	28.3%
3	5	19.2%	5	32.8%
2	2	21.9%	2	57.1%
1	3	52.2%	3	68.6%

One potential criticism that some may raise of the simulations is that they do not take into account racial data when drawing district boundaries, and that once this constraint is imposed it may shift the partisan composition of the remaining districts in a way that the distribution of simulations may look different when racial factors are explicitly considered. This criticism, however, is unwarranted, as the explicit consideration of race, if anything, actually brings the distribution of simulations more in line with the HB2146 plan.

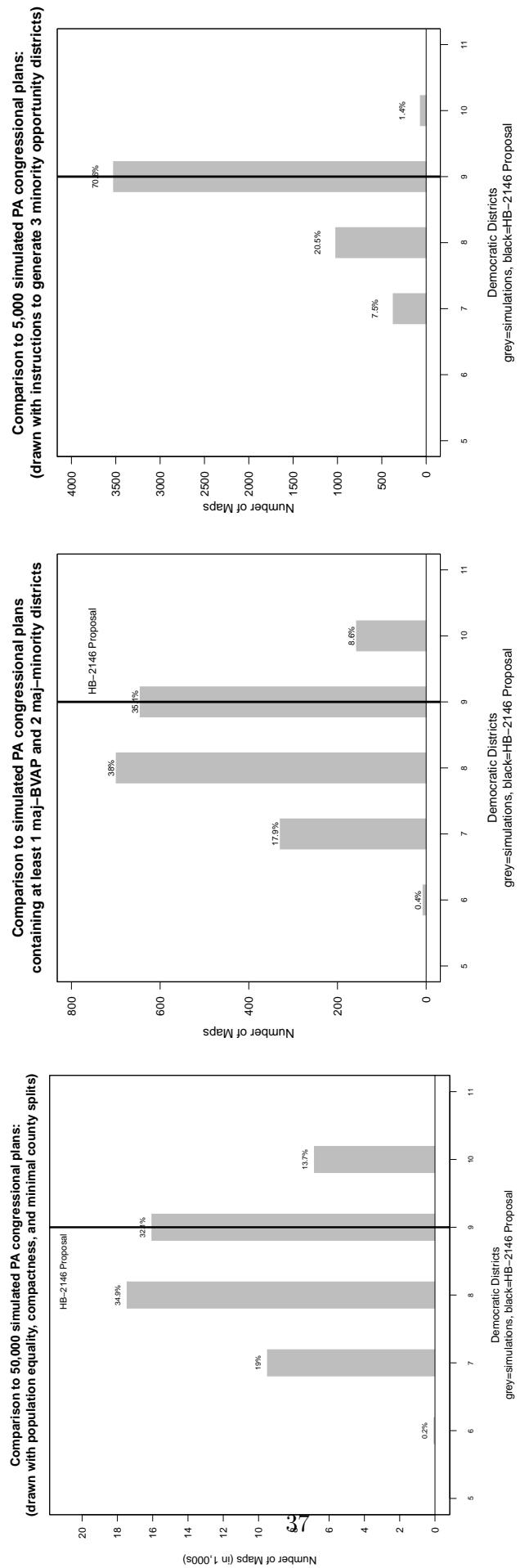
Figure 8 below shows this. The left panel of Figure 8 is the same as Figure 3 in

the earlier section of this report and shows the partisan distribution of the simulations and the location of the HB2146 plan. The middle panel of the figure subsets the race-blind simulations to the 1,842 plans that, while race was not explicitly considered, nevertheless contain both a majority-black district as well as an additional majority-minority district.³¹ Comparing the two panels shows that the distributions are extremely similar. The probability of a 9-D map, which is what the HB2146 plan generates, is nearly identical across the two sets of simulations (35.1% in the race-blind simulations, 32.1% in the race-filtered simulations).

The right panel in Figure 8 is the distribution of Democratic-leaning seats derived from a separate set of simulations that explicitly consider race. In this race-conscious set of simulations I instruct the model to ensure that every plan contains three districts that have at least a 35% non-white voting age population. These districts are often referred to as minority opportunity districts. I choose to instruct the model to generate three of these districts as it is similar to the number of minority opportunity districts generated by the HB2146 plan and the plans put forward recently by Governor Wolf. Other than the use of racial data to inform the construction of minority opportunity districts, the other parameters and data used in the two sets of simulations are identical in every other way. The right panel of Figure 8 shows that the results of the race-conscious simulations is a general reduction in the variation in the number of Democratic-leaning seats generated by the simulations. The probability of a 7-D or 8-D map has decreased substantially while there are no simulations that generate a 6-D map and only 1.4% of the simulations generate a 10-D map. A map with 9 Democratic-leaning districts is now the most common outcome with 70.6% of the simulations generating this result.

³¹While a reduction from 50,000 to 1,842 simulated plans is substantial, 1,842 is still a large number of plans to compare against and is larger than many simulations presented in other expert reports in recent redistricting litigation and is still large enough to provide a sufficient sample of maps to compare to.

Figure 8: Seats Carried by Democrats in Race-Blind and Race-Conscious Simulations



Note: The left panel contains the results of the 50,000 simulations that do not consider race when districts are drawn. The middle panel considers the 1,832 districts that, even though they were drawn without any racial data, nevertheless contain a majority Black district and an additional majority minority district. The right panel is the distribution from 5,000 simulations that are drawn with racial data and instructions to generate three districts with at least a 35% minority voting age population.

6 Conclusion

Based on the evidence and analysis presented above, my opinions regarding the HB2146 plan for congressional districts in Pennsylvania can be summarized as follows:

- The contemporary political geography of Pennsylvania is such that Democratic majorities are geographically clustered in the largest cities of the state while Republican voters dominate the suburban and rural portions of the state.
- This geographic clustering in cities puts the Democratic Party at a natural disadvantage when single-member districts are drawn. Specifically, districts drawn to be contiguous, compact, and contain minimal county and municipal splits will naturally create several districts in the Philadelphia and Pittsburgh areas that contain substantial Democratic majorities with many “wasted votes.”
- Based on a comparison between the HB2146 plan, and a set of 50,000 simulated maps, the HB2146 plan is a fair plan with no evidence of partisan gerrymandering across a number of different measures used to assess the fairness of a map.
- Based on an index of statewide elections from 2012-2020, the HB2146 plan generates nine Democratic-leaning districts and eight Republican-leaning districts.
- Based on the same index of statewide elections from 2012-2020, six of the districts in the HB2146 plan will likely be competitive with candidates from both parties having a realistic possibility of winning the seats. Five of these competitive districts are *extremely* competitive, with a partisan index within two percentage points of an even 50/50 split.
- Compared to a second set of simulations that explicitly consider the creation of minority opportunity districts, the HB2146 plan is similarly unbiased. The race-conscious simulations reduce the variation in Democratic-leaning districts substantially, mak-

ing nine Democratic-leaning districts the overwhelmingly most likely outcome in the simulations.

- Based on these commonly-used measures of redistricting fairness, the HB2146 plan is unbiased, and when compared to the simulations on these same metrics is balanced between occasionally having a slight Republican benefit and occasionally providing a slight benefit to Democratic voters.

I am being compensated for my time in preparing this report at an hourly rate of \$400/hour. My compensation is in no way contingent on the conclusions reached as a result of my analysis.

Michael Jay Barber

A handwritten signature in black ink, appearing to read "Michael Jay Barber".

7 Appendix A: Additional Statistics

Table 3: District-by-District Compactness - Polsby-Popper

District rank	District Number	Polsby-Popper
17	6	0.20
16	2	0.23
15	3	0.24
14	14	0.24
13	17	0.24
12	4	0.25
11	5	0.26
10	13	0.29
9	15	0.29
8	9	0.30
7	8	0.35
6	7	0.37
5	1	0.40
4	12	0.42
3	10	0.45
2	16	0.49
1	11	0.50

Split Municipalities:

- Philadelphia*
- Stowe Township, Allegheny County
- Centre Township, Berks County
- Summit Township, Butler County
- East Hanover Township, Butler County
- Stonycreek Township, Cambria County
- West Whiteland Township, Chester County
- Pine Creek Township, Clinton County
- Silver Spring Township, Cumberland County
- Stroud Township, Dauphin County
- Luzerne Borough, Luzerne County
- Horsham Township, Montgomery County
- Buffalo Township, Union County
- Amwell Township, Washington County
- Independence Township, Washington County
- North Franklin Township, Washington County

*Population of the city is larger than a single congressional district and therefore will need to be split between multiple districts.

Split Counties:

- Allegheny County*
- Berks County
- Butler County
- Cambria County
- Chester County
- Clinton County
- Cumberland County
- Dauphin County
- Luzerne County
- Monroe County
- Montgomery County*
- Philadelphia County*
- Snyder County
- Union County
- Washington County

*Population of the county is larger than a single congressional district and therefore will need to be split between multiple districts.

Number of Democratic-leaning Districts using Alternative Election Indices:

- All 2012-2020 statewide elections: 9
- All 2014-2020 statewide elections: 8
- 2016-2020 index used by Dave's Redistricting: 9
- Index used by Planscore.com: 8

Appendix B: Curriculum Vitae

Michael Jay Barber

CONTACT INFORMATION	Brigham Young University Department of Political Science 724 KMBL Provo, UT 84602	barber@byu.edu http://michaeljaybarber.com Ph: (801) 422-7492
ACADEMIC APPOINTMENTS	Brigham Young University , Provo, UT August 2020 - present Associate Professor, Department of Political Science 2014 - July 2020 Assistant Professor, Department of Political Science 2014 - present Faculty Scholar, Center for the Study of Elections and Democracy	
EDUCATION	Princeton University Department of Politics , Princeton, NJ Ph.D., Politics, July 2014 <ul style="list-style-type: none">• Advisors: Brandice Canes-Wrone, Nolan McCarty, and Kosuke Imai• Dissertation: “Buying Representation: the Incentives, Ideology, and Influence of Campaign Contributions on American Politics”• 2015 Carl Albert Award for Best Dissertation, Legislative Studies Section, American Political Science Association (APSA) M.A., Politics, December 2011	
	Brigham Young University , Provo, UT B.A., International Relations - Political Economy Focus, April, 2008 <ul style="list-style-type: none">• <i>Cum Laude</i>	
RESEARCH INTERESTS	American politics, congressional polarization, political ideology, campaign finance, survey research	
PUBLICATIONS	<ol style="list-style-type: none">19. “Ideological Disagreement and Pre-emption in Municipal Policymaking”, with Adam Dynes Forthcoming at <i>American Journal of Political Science</i>18. “Comparing Campaign Finance and Vote Based Measures of Ideology” Forthcoming at <i>Journal of Politics</i>17. “The Participatory and Partisan Impacts of Mandatory Vote-by-Mail”, with John Holbein <i>Science Advances</i>, 2020. Vol. 6, no. 35, DOI: 10.1126/sciadv.abc768516. “Issue Politicization and Interest Group Campaign Contribution Strategies”, with Mandi Eatough <i>Journal of Politics</i>, 2020. Vol. 82: No. 3, pp. 1008-1025	

15. “Campaign Contributions and Donors’ Policy Agreement with Presidential Candidates”, with Brandice Canes-Wrone and Sharee Thrower
Presidential Studies Quarterly, 2019, 49 (4) 770–797
14. “Conservatism in the Era of Trump”, with Jeremy Pope
Perspectives on Politics, 2019, 17 (3) 719–736
13. “Legislative Constraints on Executive Unilateralism in Separation of Powers Systems”, with Alex Bolton and Sharee Thrower
Legislative Studies Quarterly, 2019, 44 (3) 515–548
Awarded the Jewell-Loewenberg Award for best article in the area of subnational politics published in *Legislative Studies Quarterly* in 2019
12. “Electoral Competitiveness and Legislative Productivity”, with Soren Schmidt
American Politics Research, 2019, 47 (4) 683–708
11. “Does Party Trump Ideology? Disentangling Party and Ideology in America”, with Jeremy Pope
American Political Science Review, 2019, 113 (1) 38–54
10. “The Evolution of National Constitutions”, with Scott Abramson
Quarterly Journal of Political Science, 2019, 14 (1) 89–114
9. “Who is Ideological? Measuring Ideological Responses to Policy Questions in the American Public”, with Jeremy Pope
The Forum: A Journal of Applied Research in Contemporary Politics, 2018, 16 (1) 97–122
8. “Status Quo Bias in Ballot Wording”, with David Gordon, Ryan Hill, and Joe Price
The Journal of Experimental Political Science, 2017, 4 (2) 151–160.
7. “Ideologically Sophisticated Donors: Which Candidates Do Individual Contributors Finance?”, with Brandice Canes-Wrone and Sharee Thrower
American Journal of Political Science, 2017, 61 (2) 271–288.
6. “Gender Inequalities in Campaign Finance: A Regression Discontinuity Design”, with Daniel Butler and Jessica Preece
Quarterly Journal of Political Science, 2016, Vol. 11, No. 2: 219–248.
5. “Representing the Preferences of Donors, Partisans, and Voters in the U.S. Senate”
Public Opinion Quarterly, 2016, 80: 225–249.
4. “Donation Motivations: Testing Theories of Access and Ideology”
Political Research Quarterly, 2016, 69 (1) 148–160.
3. “Ideological Donors, Contribution Limits, and the Polarization of State Legislatures”
Journal of Politics, 2016, 78 (1) 296–310.
2. “Online Polls and Registration Based Sampling: A New Method for Pre-Election Polling” with Quin Monson, Kelly Patterson and Chris Mann.
Political Analysis 2014, 22 (3) 321–335.
1. “Causes and Consequences of Political Polarization” In *Negotiating Agreement in Politics*. Jane Mansbridge and Cathie Jo Martin, eds., Washington, DC: American Political Science Association: 19–53. with Nolan McCarty. 2013.
 - Reprinted in *Solutions to Political Polarization in America*, Cambridge University Press. Nate Persily, eds. 2015
 - Reprinted in *Political Negotiation: A Handbook*, Brookings Institution Press. Jane Mansbridge and Cathie Jo Martin, eds. 2015

AVAILABLE
WORKING PAPERS

“Misclassification and Bias in Predictions of Individual Ethnicity from Administrative Records” (Revise and Resubmit at *American Political Science Review*)

“Taking Cues When You Don’t Care: Issue Importance and Partisan Cue Taking”
with Jeremy Pope (Revise and Resubmit)

“A Revolution of Rights in American Founding Documents”
with Scott Abramson and Jeremy Pope (Conditionally Accepted)

“410 Million Voting Records Show the Distribution of Turnout in America Today”
with John Holbein (Revise and Resubmit)

“Partisanship and Trolleyology”
with Ryan Davis (Under Review)

“Who’s the Partisan: Are Issues or Groups More Important to Partisanship?”
with Jeremy Pope (Revise and Resubmit)

“Race and Realignment in American Politics”
with Jeremy Pope (Revise and Resubmit)

“The Policy Preferences of Donors and Voters”

“Estimating Neighborhood Effects on Turnout from Geocoded Voter Registration Records.”
with Kosuke Imai

“Super PAC Contributions in Congressional Elections”

WORKS IN
PROGRESS

“Collaborative Study of Democracy and Politics”
with Brandice Canes-Wrone, Gregory Huber, and Joshua Clinton

“Preferences for Representational Styles in the American Public”
with Ryan Davis and Adam Dynes

“Representation and Issue Congruence in Congress”
with Taylor Petersen

“Education, Income, and the Vote for Trump”
with Edie Ellison

INVITED
PRESENTATIONS

“Are Mormons Breaking Up with Republicanism? The Unique Political Behavior of Mormons in the 2016 Presidential Election”

- Ivy League LDS Student Association Conference - Princeton University, November 2018, Princeton, NJ

“Issue Politicization and Access-Oriented Giving: A Theory of PAC Contribution Behavior”

- Vanderbilt University, May 2017, Nashville, TN

"Lost in Issue Space? Measuring Levels of Ideology in the American Public"

- Yale University, April 2016, New Haven, CT

"The Incentives, Ideology, and Influence of Campaign Donors in American Politics"

- University of Oklahoma, April 2016, Norman, OK

"Lost in Issue Space? Measuring Levels of Ideology in the American Public"

- University of Wisconsin - Madison, February 2016, Madison, WI

"Polarization and Campaign Contributors: Motivations, Ideology, and Policy"

- Hewlett Foundation Conference on Lobbying and Campaign Finance, October 2014, Palo Alto, CA

"Ideological Donors, Contribution Limits, and the Polarization of State Legislatures"

- Bipartisan Policy Center Meeting on Party Polarization and Campaign Finance, September 2014, Washington, DC

"Representing the Preferences of Donors, Partisans, and Voters in the U.S. Senate"

- Yale Center for the Study of American Politics Conference, May 2014, New Haven, CT

CONFERENCE PRESENTATIONS

Washington D.C. Political Economy Conference (PECO):

- 2017 discussant

American Political Science Association (APSA) Annual Meeting:

- 2014 participant and discussant, 2015 participant, 2016 participant, 2017 participant, 2018 participant

Midwest Political Science Association (MPSA) Annual Meeting:

- 2015 participant and discussant, 2016 participant and discussant, 2018 participant

Southern Political Science Association (SPSA) Annual Meeting:

- 2015 participant and discussant, 2016 participant and discussant, 2017 participant

TEACHING EXPERIENCE

Poli 315: Congress and the Legislative Process

- Fall 2014, Winter 2015, Fall 2015, Winter 2016, Summer 2017

Poli 328: Quantitative Analysis

- Winter 2017, Fall 2017, Fall 2019, Winter 2020, Fall 2020, Winter 2021

Poli 410: Undergraduate Research Seminar in American Politics

- Fall 2014, Winter 2015, Fall 2015, Winter 2016, Summer 2017

AWARDS AND GRANTS	2019 BYU Mentored Environment Grant (MEG), American Ideology Project, \$30,000 2017 BYU Political Science Teacher of the Year Award 2017 BYU Mentored Environment Grant (MEG), Funding American Democracy Project, \$20,000 2016 BYU Political Science Department, Political Ideology and President Trump (with Jeremy Pope), \$7,500 2016 BYU Office of Research and Creative Activities (ORCA) Student Mentored Grant x 3 <ul style="list-style-type: none">• Hayden Galloway, Jennica Peterson, Rebecca Shuel 2015 BYU Office of Research and Creative Activities (ORCA) Student Mentored Grant x 3 <ul style="list-style-type: none">• Michael-Sean Covey, Hayden Galloway, Sean Stephenson 2015 BYU Student Experiential Learning Grant, American Founding Comparative Constitutions Project (with Jeremy Pope), \$9,000 2015 BYU Social Science College Research Grant, \$5,000 2014 BYU Political Science Department, 2014 Washington DC Mayoral Pre-Election Poll (with Quin Monson and Kelly Patterson), \$3,000 2014 BYU Social Science College Award, 2014 Washington DC Mayoral Pre-Election Poll (with Quin Monson and Kelly Patterson), \$3,000 2014 BYU Center for the Study of Elections and Democracy, 2014 Washington DC Mayoral Pre-Election Poll (with Quin Monson and Kelly Patterson), \$2,000 2012 Princeton Center for the Study of Democratic Politics Dissertation Improvement Grant, \$5,000 2011 Princeton Mamdouha S. Bobst Center for Peace and Justice Dissertation Research Grant, \$5,000 2011 Princeton Political Economy Research Grant, \$1,500
OTHER SCHOLARLY ACTIVITIES	Expert Witness in Nancy Carola Jacobson, et al., Plaintiffs, vs. Laurel M. Lee, et al., Defendants. Case No. 4:18-cv-00262 MW-CAS (U.S. District Court for the Northern District of Florida) Expert Witness in Common Cause, et al., Plaintiffs, vs. LEWIS, et al., Defendants. Case No. 18-CVS-14001 (Wake County, North Carolina) Expert Witness in Kelvin Jones, et al., Plaintiffs, v. Ron DeSantis, et al., Defendants, Consolidated Case No. 4:19-cv-300 (U.S. District Court for the Northern District of Florida) Expert Witness in Community Success Initiative, et al., Plaintiffs, v. Timothy K. Moore, et al., Defendants, Case No. 19-cv-15941 (Wake County, North Carolina) Expert Witness in Richard Rose et al., Plaintiffs, v. Brad Raffensperger, Defendant, Civil Action No. 1:20-cv-02921-SDG (U.S. District Court for the Northern District of Georgia)

Georgia Coalition for the People's Agenda, Inc., et. al., Plaintiffs, v. Brad Raffensberger, Defendant. Civil Action No. 1:18-cv-04727-ELR (U.S. District Court for the Northern District of Georgia)

Expert Witness in Alabama, et al., Plaintiffs, v. United States Department of Commerce; Gina Raimondo, et al., Defendants. Case No. CASE No. 3:21-cv-00211-RAH-ECM-KCN (U.S. District Court for the Middle District of Alabama Eastern Division)

Expert Witness in League of Women Voters of Ohio, et al., Relators, v. Ohio Redistricting Commission, et al., Respondents. Case No. 2021-1193 (Supreme Court of Ohio)

Expert Witness in Regina Adams, et al., Relators, v. Governor Mike DeWine, et al., Respondents. Case No. 2021-1428 (Supreme Court of Ohio)

Expert Witness in Rebecca Harper, et al., Plaintiffs, v. Representative Destin Hall, et al., Defendants (Consolidated Case). Case No. 21 CVS 500085 (Wake County, North Carolina)

ADDITIONAL
TRAINING

EITM 2012 at Princeton University - Participant and Graduate Student Coordinator

COMPUTER
SKILLS

Statistical Programs: R, Stata, SPSS, parallel computing

Updated January 7, 2022

EXPERT REPORT OF JONATHAN RODDEN, Ph.D.

Carter v. Chapman, 464 MD 2021, 465 MD 2021 (Pa. Commw. Ct.)
January 26, 2022

In this report, I provide a brief analysis of a set of 13 Pennsylvania congressional redistricting plans that were provided to me on January 24. I have been asked to provide a basic analysis of these plans, and to compare them with a redistricting plan, called the “Carter Plan,” that I submitted in this case on January 24. Please see my previous report for a discussion of my qualifications and relevant experience.

First, I assess the extent to which these plans place voters in different districts than those of the 2018 Remedial Plan ordered by the Pennsylvania Supreme Court four years ago. Second, I assess these plans according to several traditional redistricting criteria, including population equality, contiguity, compactness, and splits of counties, county subdivisions, and vote tabulation districts. Third, I assess the likely partisan outcomes associated with these plans.

I. DEVIATION FROM THE PREVIOUS REDISTRICTING PLAN

In the expert report I submitted in this case on January 24, I explained that the Carter Plan was explicitly crafted to minimize the changes from the 2018 Remedial Plan, which had only been in place for two elections. This choice was made because the Pennsylvania Supreme Court had very recently endorsed this plan as meeting all its objective criteria.

I measured the extent to which each of the submitted plans places voters in the same district as in the previous 2018 plan. Note that some district numbers have changed. For each district in each submitted plan, the task is to find the overlapping fragments of districts from the previous plan and identify the largest one. I then calculate the share of all voters in the proposed new district living in that largest fragment. For instance, since Bucks County is in the corner of the state and has a population relatively close to the required population for a congressional district, most map-drawers drew a district that was dominated by Bucks County, adding in some municipalities on the Western or Southern edge of the district in Montgomery or Philadelphia, just as the previous plan had done. For this Bucks County-oriented district, many of the plans had what I will call a “retained population share” of over 90 percent. However, as explained in my earlier report, these shares were necessarily much lower in Central Pennsylvania in all the plans, because rural population loss required more substantial changes.

Some of the plans also introduced major changes in metro areas. For instance, while the 2018 Remedial Plan kept the city of Pittsburgh whole, some plans, including the Governor’s plan, opted to split it. The plan introduced in HB2146 pursues a different orientation of the Pittsburgh area altogether, adding a number of more rural, Republican communities to what was previously a very competitive but Republican-leaning district.

I have calculated the average “retained population share” across all the districts in each plan, and I report this quantity in Table 1.

Table 1: Retained Population Share in 14 Submitted PA Congressional Plans

Plan	Retained Population Share
Carter	86.6
CCFD	76.1
Citizen Voters	82.4
HB2146	78.5
Draw the Lines PA	78.8
GMS	72.8
Governor Wolf	81.2
Ali	81.5
PA House Dem. Caucus	73.3
Reschenthaler 1	76.5
Reschenthaler 2	76.5
Senate Dem. Plan 1	72.5
Senate Dem. Plan 2	72.5
Voters of PA	80.6

Not surprisingly, since the Carter Plan explicitly set out to minimize boundary changes, its districts retain more of their former population—around 87 percent—than any of the submitted plans. The plans that make the largest changes are the Senate Democratic plans, the GMS plan, and the House Democratic Caucus plan.

II. TRADITIONAL REDISTRICTING CRITERIA

Population Equality

The ideal population for a Pennsylvania Congressional District in the 2022 round of redistricting is 764,865. Each of the maps, including the Carter Plan, creates 17 districts where the population, according to the 2020 Census, is either precisely that number, one more, or one less. The only exception is the map submitted by Khalif Ali, where the districts were drawn using the Legislative Reapportionment Commission’s Data Set #2, which contains population adjustments to account for the reallocation of most prisoners to their last known address prior to incarceration. When analyzed using the Census data or Legislative Reapportionment Commission’s Data Set #1, the Ali map results in districts that have population deviations of up to several thousand people. But it purports to be equally populated under Data Set #2, and I did not analyze its population equality under that data set.

Given ongoing residential moves, measurement error, and the efforts of the census department to protect privacy, deviations of zero or a single voter from “perfect” equality are a form of what is commonly referred to as “false precision.” Given measurement error and population churn, even plans with zero population deviation in every district are unlikely to be *truly* equal in population.

The best we can say is that in each of these plans, populations are as close to equal as is possible given the constraints of the data.

Contiguity

Each of the maps, including the Carter Plan, has districts made up of contiguous territory. The only potential exception is the CCFD map, which includes a zero-population noncontiguous census block in District 9.

Compactness

All the maps I received include relatively compact districts. There is no widely accepted “best” measure of compactness, and each measure achieves something different. Two measures of compactness often considered by courts are the Polsby-Popper score and the Reock score. The Polsby-Popper score is the ratio of the area of the district to the area of a circle whose circumference is equal to the perimeter of the district. This score rewards districts with smooth perimeters and penalizes those with more contorted borders. To the extent that jagged borders are sometimes caused by natural features, like rivers separating counties, coastlines, or boundaries of cities that have experienced odd-shaped annexations over the years, the Polsby-Popper score might serve as a rather poor indicator of political manipulation. If one map-drawer chooses to keep an odd-shaped city whole, and another elects to split the city cleanly down the middle, the first map-drawer will end up with a district with a lower Polsby-Popper score. Likewise, if one district-drawer chooses to keep a county whole—but the county’s boundary is a meandering river—this district will have a lower Polsby-Popper score than that of another district-drawer who chooses to split the county along a smooth municipal boundary.

The Reock score is computed by dividing the area of the district by the area of the smallest circle that would completely enclose it. The downside of this measure is that it can be sensitive to the orientations of a district’s extremities. A rather odd-shaped district, for example one resembling a coiled snake, might still end up with a low Reock score if its stays nicely within the bounding circle. Fortunately, the districts submitted to the Court are not rife with such odd-shaped districts.

In general, the compactness scores all fall within a relatively narrow range. None of the submitted plans features highly non-compact districts with tentacles, claws, and the like.

Splits of Jurisdictions

Some maps- are more successful than others in keeping political subdivisions whole. Table 1 provides information about county splits in the submitted plans. It makes a subtle distinction between the number of split counties and the total number of county splits. The number of split counties is, quite simply, the number of counties that were not kept whole, regardless of how many splits they experienced. However, some counties were split multiple times. Many of the maps, for instance, split Philadelphia, Montgomery, or Berks County among three rather than just two districts. And some of the plans extracted separate chunks of the same county in different regions of the county. The last column in Table 1 adds up the *total* number of splits, such that a county

split between three districts counts as two splits rather than one, and two non-contiguous splits of the same county are both counted.

Table 2:
County Splits in 14 Submitted Congressional Plans

Plan	Number of Split Counties	Total County Splits
Carter	14	17
CCFD	16	20
Citizen Voters	14	17
HB2146	15	20
Draw the Lines PA	14	18
GMS	15	19
Governor Wolf	16	22
Ali	16	20
PA House Dem. Caucus	16	18
Reschenthaler 1	13	18
Reschenthaler 2	13	18
Senate Dem. Plan 1	17	20
Senate Dem. Plan 2	16	18
Voters of PA	15	17

The two Reschenthaler plans split 13 counties, while the Carter, Citizen Voters, and Draw the Lines PA plans split 14. Note that in my previous report, I adopted the Pennsylvania Supreme Court's logic, arguing that the Carter Plan's split of only 6 people in order to preserve contiguity while avoiding a split of Chester County should not be counted, and the true number of split counties in the Carter Plan is actually 13 instead of 14. However, since I have not had the opportunity to assess such technicalities in each of the 13 other plans, Table 2 counts even these tiniest splits wherever they occur. The largest number of split counties, 17, is found in Senate Democratic Plan 1. However, if we focus on *total* splits, the Carter Plan, Citizen Voters Plan, and Voters of PA plans demonstrate the lowest number of splits, 17, and the Governor's Plan demonstrates the largest number of splits, 22.

One might imagine that a low number of split counties goes hand in hand with higher levels of compactness, but for reasons described above, this is not necessarily the case. Figure 1 plots the Reock Score against the total number of county splits in each plan. There is only a weak negative relationship. Figure 1 shows that the "Voters of Pennsylvania" plan and the Carter Plan are the most compact, according to the Reock Score, and have the lowest number of total county splits.

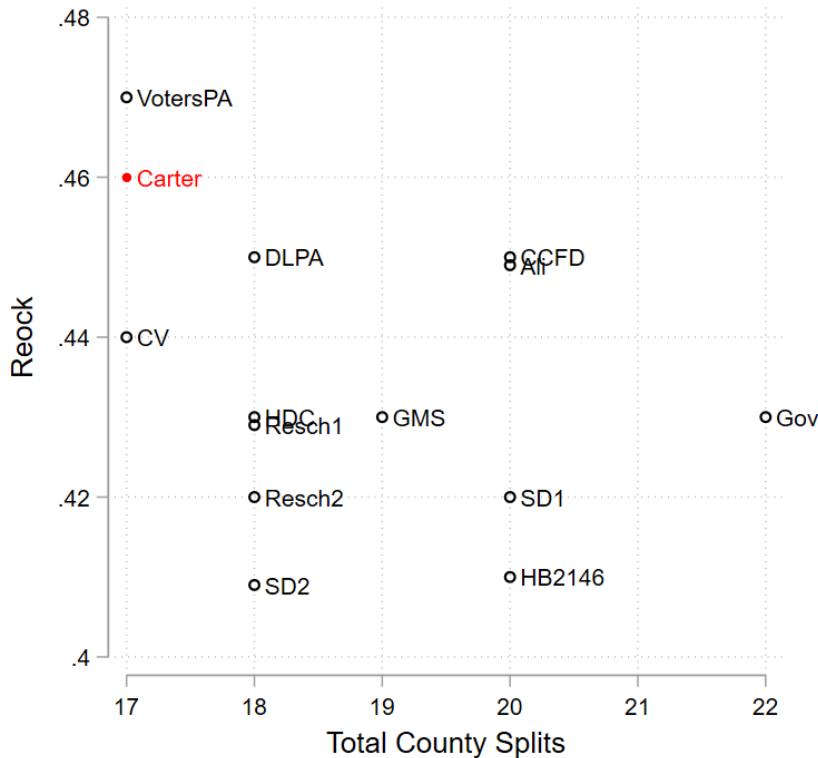
Figure 1: Reock Compactness Score and Total County Splits, 14 Submitted Plans

Table 3 examines splits in the boundaries of County subdivisions, using geo-spatial boundaries curated by the U.S. Census Department. The Carter Plan splits 20 such subdivisions, while the lowest number of subdivisions splits is demonstrated by the CCFD Plan, with 14. When it comes to *total* County Subdivision splits, the Carter Plan is in the middle of the distribution across plans.

Table 3: County Subdivision Splits in 14 Submitted Congressional Plans

Plan	Number of Split County Subdivisions	Total County Subdivision Splits
Carter	20	23
CCFD	14	18
Citizen Voters	16	21
HB2146	16	25
Draw the Lines PA	16	23
GMS	16	26
Governor Wolf	17	35
Ali	18	24
PA House Dem. Caucus	18	20
Reschenthaler 1	15	22
Reschenthaler 2	15	22
Senate Dem. Plan 1	19	22
Senate Dem. Plan 2	16	18
Voters of PA	18	26

In the world of election administration, it is especially useful to avoid splitting vote tabulation districts (VTDs). Above all, split VTDs can lead to mistakes for local election administrators, who must be sure to provide the right ballot for residents living in two different political districts, even though they might be voting at the same polling place. However, when a redistricting plan is aiming to seek population equality within a very narrow allowable deviation, like plus or minus one person, it is often not possible to avoid splitting a VTD somewhere along the boundary of two districts, since the VTD populations simply do not add to precisely the right numbers. Nevertheless, it is possible to minimize these splits. Table 4 provides the number of VTDs that were split by each plan.

Table 4: Split Vote Tabulation Districts in 14 Submitted PA Congressional Plans

Plan	Number of Split VTDs
Carter	14
CCFD	16
Citizen Voters	26
HB2146	9
Draw the Lines PA	23
GMS	17
Governor Wolf	17
Ali	27
PA House Dem. Caucus	16
Reschenthaler 1	31
Reschenthaler 2	31
Senate Dem. Plan 1	16
Senate Dem. Plan 2	16
Voters of PA	16

The two plans with the lowest number of split VTDs are HB2146 and the Carter Plan. The plans with the most split VTDs are the Reschenthaler plans and the Ali Plan.

III. PARTISAN FAIRNESS AND COMPETITION

A final task is to assess whether the plans are fair to both political parties. As explained in my initial report submitted in this case, if we look at statewide elections in recent years, around 52 to 53 percent of votes for the two major parties go to Democrats. The 2018 Remedial Plan had 18 districts, and the Congressional delegation was evenly split, 9 to 9. Given the overall statewide vote share, this map gave a slight advantage in practice to the Republican Party, though as pointed out in my earlier report, it is important not to be misled by simple seat counts without a closer look at the underlying partisanship of districts and the role of incumbency. Several districts in the previous plan were relatively balanced, both in terms of statewide partisanship and actual congressional elections, and one district—District 1 in Bucks County—leaned toward Democratic candidates in statewide races but consistently elected a Republican Congressional representative.

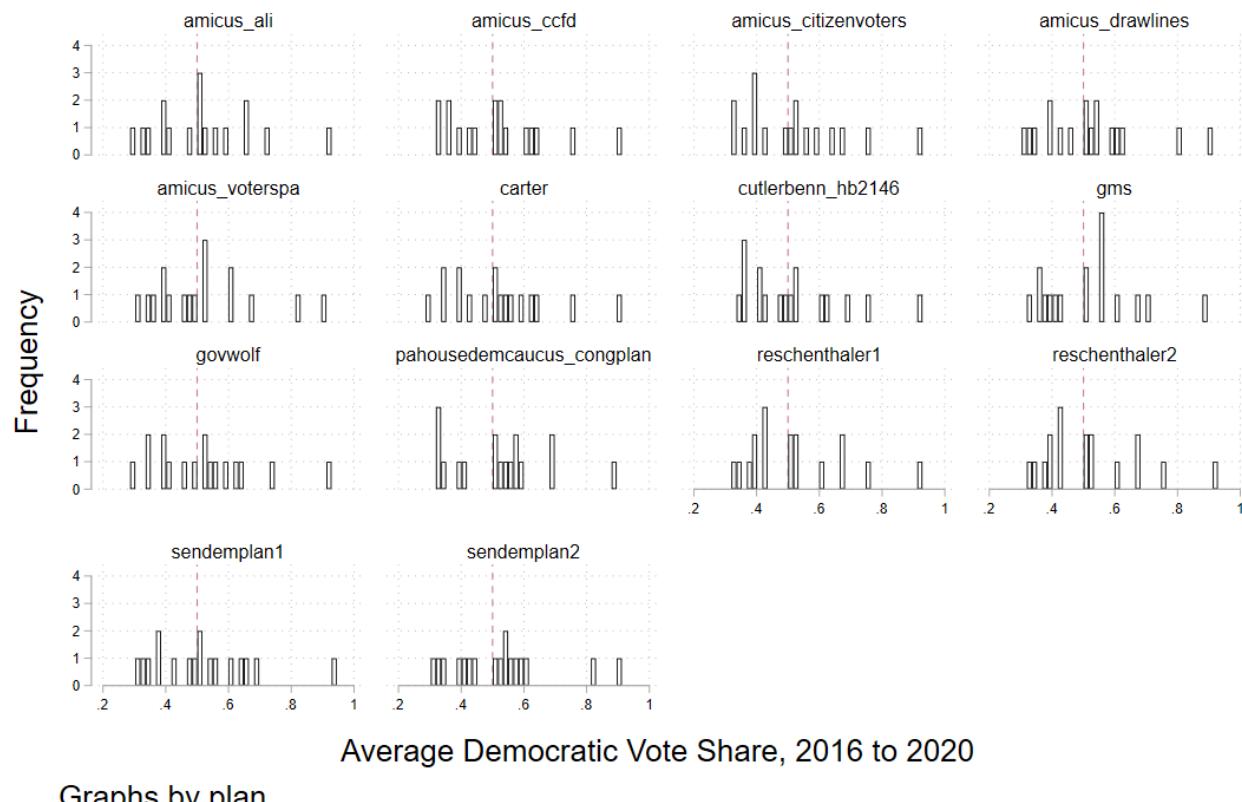
Now there is an odd number of districts, so a tied delegation is no longer possible. Given the Democrats' advantage in the statewide vote share, one would anticipate that the Democratic Party would be able to win a majority of congressional seats as well, especially since, as detailed in my previous report, population has been declining in Republican areas and increasing in Democratic areas, with Democratic support also *growing* in the areas that are gaining population.

As I have described elsewhere,¹ Pennsylvania's political geography is such that at the scale of congressional districts, Democratic and Republican areas are in sufficient proximity to one another—above all, along the Eastern side of the state and in the Pittsburgh suburbs—that it should also be possible to sustain some competitive districts that will change hands between the parties as voters' preferences change.

To examine partisanship, as in my previous report, I have aggregated the precinct-level votes for the two parties in all the statewide elections from 2016 to 2020 and calculated the average share of the vote for each of the two major parties in each district. A good way to visualize the result of this exercise is with Figure 2, which provides histograms of the Democratic vote share across districts for each plan. The 50 percent point is indicated with a dashed red line. On the left-hand side of the line are districts that Republicans can anticipate winning, and on the right-hand side are the districts that Democrats can expect to win. When the bars are higher, this indicates that there are multiple districts in that bin. The height of the bin corresponds to the number of districts in that bin. For instance, we can see that the Ali Plan has three districts that are very close to evenly divided between the parties. We also can see that all the plans have exceptionally Democratic districts on the right-hand side of the graph because most of them keep the very Democratic neighborhoods of Philadelphia together.

¹ Jonathan Rodden, *Why Cities Lose: The Deep Roots of the Urban-Rural Political Divide*. New York: Basic Books.

Figure 2:
The Distribution of Partisanship Across Districts of 14 Submitted Congressional Plans



One way to use the data in Figure 2 is to simply add up the districts that are on either side of the red line. How many districts have Democratic majorities in these statewide races, however small, and how many have Republican majorities?

If we are interested in competitive districts, we can also ask how many seats are in the bins closest to the red lines in Figure 2. I have calculated the number of seats in each plan between 50 percent Democratic and 52 percent Democratic, and those between 50 percent Republican and 52 percent Republican, using statewide elections from 2016 to 2020. This information is set forth in Table 5 below.

Table 5: Number of Seats in Various Categories, 14 Submitted Congressional Plans

Plan	# of seats with statewide Dem vote share >.5	# of seats with statewide Dem vote share >.52	# of seats with statewide Dem vote share between .5 and .52	# of seats with statewide Rep vote share between .5 and .52	# of seats with statewide Rep vote share >.52	# of seats with statewide Dem vote share >.5
Ali	10	7	3	0	7	7
CCFD	10	8	2	0	7	7
Citizen Voters	9	8	1	1	7	8
Draw the Lines PA	10	8	2	0	7	7
Voters of PA	8	8	0	2	7	9
Carter	10	8	2	0	7	7
HB2146	8	7	1	2	7	9
GMS	10	8	2	0	7	7
Governor Wolf	9	9	0	1	7	8
PA House Dem. Caucus	11	9	2	0	6	6
Reschenthaler 1	9	6	3	0	8	8
Reschenthaler 2	9	7	2	0	8	8
Senate Dem. Plan 1	9	7	2	1	7	8
Senate Dem. Plan 2	10	9	1	0	7	7

In most of the plans, either 9 or 10 seats have average Democratic vote shares above 50 percent (see the first column in Table 5). However, one can look at Figure 2 above, or at the middle columns in Table 5, to see that typically, anywhere from one to three of the nominally Democratic districts are very close to 50 percent. In the Carter Plan, two of the Democratic-leaning districts, as determined by statewide elections, are in this category. These are usually in the Lehigh Valley, the Northeast, and/or suburban Pittsburgh. In other words, by no means does this analysis tell us the Democrats will win 10 seats in, for instance, the GMS plan. Figure 2 and Table 5 tell us that two of the districts in this plan are essentially toss-ups based on the statewide data.

In the Carter Plan, there are 10 Democratic-leaning districts, but two of them are very close to toss-ups, yet there are no Republican-leaning toss-ups. Thus, based purely on statewide election data, the Carter Plan could easily lead to a 9-8 Republican majority.

However, as I explained in my earlier report, the statewide analysis in Table 5 is potentially quite flawed. I pointed out that the Republican incumbent in Bucks County, Brian Fitzpatrick, typically outperforms his party by over 7 percentage points. As mentioned above, the Bucks County district experiences very little change in all these plans. As a result, all these plans include a district with a statewide Democratic vote share above 50 percent where the Republican incumbent is very likely to win. In fact, in many of these plans, including the Carter Plan, Table 5 categorizes the district

in which Rep. Fitzpatrick wins by large margins as a relatively comfortable *Republican* district. In other words, if the goal of the first column of Table 5 is to predict Democratic wins, one seat should be moved from the far-left Democratic column in Table 5 to the far-right Republican column.. The anticipated number of Democratic seats in the Carter Plan, for example, is 9, not 10 if we consider this important fact.

Three plans are outliers: First, HB2146 and the “Voters of PA” plan both produce a minority of Democratic-leaning seats in spite of the Democrats’ overall statewide majorities during this period. This is especially noteworthy if we account for the incumbent in the Bucks County-based district and recognize that these plans are likely to produce only 7 Democratic seats (i.e. 41 percent of the seats in a state where Democrats get more than 52 percent of the vote).

The Reschenthaler 1 and Reschenthaler 2 plans also stand out, in that they produce 8 comfortable Republican seats, not including Rep. Fitzpatrick’s seat, and an unusually low number of comfortable Democratic seats, achieving a nominal, and potentially misleading, total of 9 Democratic-leaning seats by producing either 2 or 3 toss-up seats that lean Democratic.

The Senate Democratic Plan Number 1, too, produces fewer comfortable Democratic seats than almost every other plan.

In the other direction, the Pennsylvania House Democratic Caucus is an outlier in that it is the only plan with 11 seats above the 50 percent Democratic threshold. Governor Wolf’s Plan, as well as the Senate Democratic Plan Number 2 are unusual in that they produce only 1 district in the 50 to 52 percent range for either political party.

The HB2146 and “Voters of PA” plans, as well as the Reschenthaler plans, also stand out in another respect. Using the 2016 to 2020 statewide average, I have calculated the mean Democratic vote share across all the districts in each plan, as well as the median Democratic vote share in each plan. The mean and median are almost identical in all the plans, with the exception of these three. In HB2146, the average Democratic vote share is higher by 2.4 percentage points than the median Democratic vote share. In the “Voters of PA” plan, it is higher by 2.6 percentage points. In the Reschenthaler plans, the difference is 1 percentage point. This simple statistic captures the fact—also evident in Figure 2 above, that the distribution of Democratic vote shares across districts is unusually skewed in these plans. Democrats are quite concentrated in districts that they win with large majorities, in the right tail of the distributions depicted in Figure 2, and there is a large density of districts that Republicans win by comfortable, but not overwhelming, majorities, to the left of the red lines in Figure 2. This results in a mean Democratic vote share that is higher than the median. We do not see a similar skew in the cross-district distributions for any of the other plans.

Table 6: Mean-Median Difference for 14 Submitted Congressional Plans.

Plan	Mean Median Difference
Ali	0.004
Carter	0.005
CCFD	0.005
Citizen Voters	0.014
Draw the lines	0.006
GMS	0.005
Gov. Wolf	0.006
HB2146	0.024
HDC	0.004
Reschenthaler 1	0.01
Reschenthaler 2	0.01
Sen Dems 1	0.007
Sen Dems 2	0.007
Voters of PA	0.026

IV. CONCLUSION

The 14 plans reviewed in this report are in a relatively narrow band when it comes to population equality, county, county subdivision, and vote tabulation district splits, as well as compactness. The Carter Plan was more faithful than the others to the original 2018 districts and preserved more of the population of these districts within the proposed new districts. It also ranks at or near the top of the plans in terms of county and VTD splits, and the Reock compactness score.

Most of the plans produce either 9 or 10 districts in which Democratic statewide candidates have received majorities in recent years. The Carter Plan produces 10. It should be noted, however, that in most of these plans, including the Carter Plan, one of those districts is quite likely to be won by a Republican incumbent, so that the most likely outcome is 8 or 9 Democratic members of Congress. Two plans, the HB2146 plan and the “Voters of PA” Plan, are clearly more favorable to Republican candidates, and would likely lead to counter-majoritarian outcomes. Another plan, produced by the House Democratic Caucus, is unusually advantageous to the Democratic Party.

Ultimately, when one considers only those plans that accurately reflect Pennsylvanians’ statewide voter preferences, then the Carter Plan does best (or ties for best) on the Reock compactness score, county splits, and VTD splits and retains the most voters in their 2018 districts.

I hereby certify that the foregoing statements are true and correct to the best of my knowledge, information, and belief. This verification is made subject to the penalties of 18 Pa.C.S. § 4904 relating to unsworn falsification to authorities.



Jonathan Rodden

January 26, 2022